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REVISION 3

U.S. NAVY DIVING MANUAL
VOLUME 2
(MIXED-GAS DIVING)

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In the early 1960's, a young diving enthusiast from Switzerland, Hannes Keller, proposed techniques to attain great depths while minimizing decompression requirements. Using a series of gas mixtures containing varying concentrations of oxygen, helium, nitrogen, and argon, Keller demonstrated the value of elevated oxygen pressures and gas sequencing in a series of successful dives in mountain lakes. In 1962, with partial support from the U.S. Navy, he reached an open sea depth of more than 1000 feet off the California coast. Unfortunately, this dive was marred by tragedy. Through a mishap unrelated to the technique itself, Keller lost consciousness on the bottom and, in the subsequent emergency decompression, Keller's companion died of decompression sickness.

By the late 1960's, it was clear that surface supplied diving deeper than 300 feet was better carried out using a deep diving (bell) system (see Paragraph 9.3.4), where the gas sequencing techniques pioneered by Hannes Keller could be exploited to full advantage and the diver maintained in a state of comfort and security. The U.S. Navy developed decompression procedures for bell diving systems in the late 1960's and early 1970's. For surface supplied diving in the 0-300 fsw range, attention was turned to the development of new equipment to replace the cumbersome MK V MOD 1 helmet.

The new equipment development proceeded along two parallel paths, the development of open circuit demand breathing systems, suitable for deep helium oxygen diving, and the development of an improved recirculating helmet as a direct replacement of the MK V MOD 1. By the late 1960's, engineering improvements in demand regulators had reduced breathing resistance on deep dives to acceptable levels. Masks and helmets incorporating these new regulators had become commercially available. In 1976, the U.S. Navy approved the MK 1 MOD 0 Lightweight Mixed Gas Diving Outfit for dives to 300 fsw on helium oxygen (Figure 9-6). The MK 1 MOD 0 Diving Outfit incorporated a full face mask (bandmask) featuring a demand open circuit breathing regulator and a backpack for an emergency gas supply. Sur-

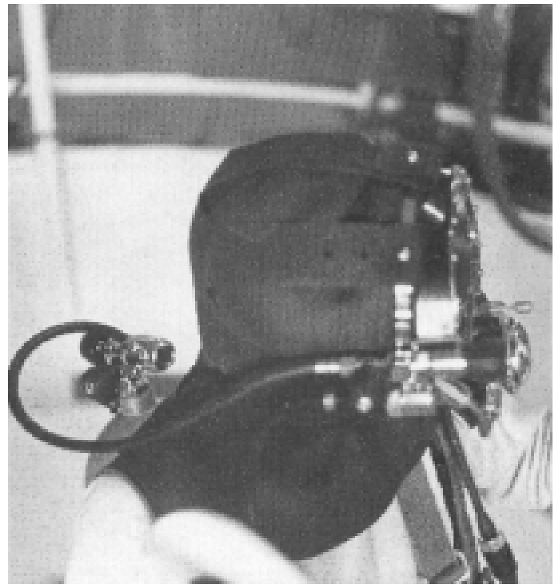

Figure 9-6. Navy MK 1 MOD 0 Diver's

Figure 9-7. MK 12 and MK 5.

Figure 9-8. MK 12 Surface-Supplied Diving

face contact was maintained through an umbilical which included the breathing gas hose, communications cable, lifeline strength member, and pneumofathometer hose. The diver was dressed in a dry suit or hot water suit depending on water temperature. The equipment was issued as a lightweight diving outfit in a system which included sufficient equipment to support a diving operation employing two working divers and a standby diver. The outfit was used in conjunction with an open diving bell which replaced the traditional diver's stage and added additional safety. In 1990, the MK 1 MOD 0 was replaced by the MK 21 MOD 1 (Superlite 17 B/NS) demand helmet which is the lightweight rig in use today (Paragraph 10.10.4).

In 1985, the replacement for the MK V MOD 1 helmet was approved for Fleet use. The MK 12 Mixed Gas Surface Supplied Diving System (SSDS) is similar to the MK 12 air SSDS, with the addition of a backpack assembly to allow operation in a semi closed circuit mode (refer to Figures 9-7 and 9-8). The MK 12 system was retired in 1992.

9.3.3 Development of Mixed Gas UBA Diving. In the late 1940's, Lambertsen proposed that mixtures of nitrogen or helium with an elevated oxygen content be used in SCUBA to expand the depth range beyond that allowed by 100 percent oxygen rebreathers, while simultaneously minimizing the requirement for decompression. In the early 1950's, he introduced a semi closed circuit UBA called the FLATUS I which operated on the principle of a continuous addition of a small volume of mixed gas (rather than pure oxygen) to a rebreathing circuit. The small volume of new gas provided the oxygen necessary for metabolic consumption while exhaled carbon dioxide was absorbed in an absorbent canister. Since inert gas as well as oxygen was added to the rig, and since the inert gas was not consumed by the diver, a small amount of gas mixture was continuously exhausted from the rig.

Figure 9-9. MK 6 UBA.

EMERGENCY ASSISTANCE CHECKLIST

RECOMPRESSION CHAMBER	GAS SUPPLIES
Location ____________	Location ____________
Point of Contact ____________	Point of Contact ____________
Phone Number ____________	Phone Number ____________
Response Time ____________	Response Time ____________
AIR TRANSPORTATION	**COMMUNICATIONS**
Location ____________	Location ____________
Point of Contact ____________	Point of Contact ____________
Phone Number ____________	Phone Number ____________
Response Time ____________	Response Time ____________
SEA TRANSPORTATION	**DIVING UNITS**
Location ____________	Location ____________
Point of Contact ____________	Point of Contact ____________
Phone Number ____________	Phone Number ____________
Response Time ____________	Response Time ____________
HOSPITAL	**COMMAND**
Location ____________	Location ____________
Point of Contact ____________	Point of Contact ____________
Phone Number ____________	Phone Number ____________
Response Time ____________	Response Time ____________
DIVING MEDICAL OFFICER	**EMERGENCY CONSULTATION** Duty Phone Numbers 24 Hours a Day
Location ____________	NAVY EXPERIMENTAL DIVING UNIT (NEDU) Commercial (904) 230-3100 (904) 235-1668 Autovon 436-4351
Point of Contact ____________	
Phone Number ____________	**NAVAL MEDICAL RESEARCH INSTITUTE (NMRI)**
Response Time ____________	Commercial (301) 295-1839 Autovon 295-1839

Figure 10-1. Emergency Assistance Checklist.

Table 2-1. Average Breathing Gas Consumption Rates and CO_2 Absorbent Usage.

Diving Equipment	Overbottom Pressure (Minimum)	Gas Consumption (Normal)	Gas Consumption (Heavy Work)	CO_2 Absorbent		
				Capacity (lbs.)	Duration 40°F (Note 1)	Duration 70°F (Note 1)
LAR V UBA (100% O_2)	72.5 psi	15-17 psi/min	Note 2	5.56	1h 55m	3h 20m
MK 15 UBA (Mixed gas)	110-150 psi	12-15 psi/min	15-17 psi/min	7.25	2h	6h 40m
MK 16 UBA (Mixed gas)	Variable with bottle pressure	12-15 psi/min	15-17 psi/min	7.75-8.0	5h	6h 40m
MK 21 MOD 1 UBA	135 psi	1.4 acfm (demand) 6.0 acfm (free flow)	2.5 acfm (demand) 6.0 acfm (free flow)	N/A	N/A	N/A
MK 21 MOD 0 UBA	185 psi	1.4 acfm (demand) 6.0 acfm (free flow)	2.5 acfm (demand) 6.0 acfm (free flow)	N/A	N/A	N/A
MK 22 MOD 0 UBA	185 psi	1.4 acfm (demand) 6.0 acfm (free flow)	2.5 acfm (demand) 6.0 acfm (free flow)	N/A	N/A	N/A

Notes:

1. CO_2 absorbent duration is based upon a comfortable work rate (0.8 knot swimming speed).
2. Heavy work is not recommended for the LAR V.

personnel procurement (refer to OPNAVINST 3120.32A).

b. Mixed-gas diving poses greater hazards to divers than air diving. Therefore, the importance of medical considerations, including decompression, is amplified and must be considered in detail when planning for support personnel. A Master Diver must be on site for all surface-supplied mixed-gas diving operations and for all saturation dives. A Diving Medical Officer must be on site for all dives exceeding the normal working limit and for all saturation dives.

10.5 SELECT DIVING METHOD AND EQUIPMENT

The selection of an appropriate diving method is essential to any diving operations planning. The method will dictate many aspects of an operation including personnel and equipment.

10.5.1 Mixed-Gas Diving Methods. Mixed-gas diving methods are defined by which of the three types of mixed-gas diving equipment will be used. These types are:

- Surface-supplied lightweight gear (MK 21 MOD 1)
- Closed-circuit UBAs
- Saturation deep dive systems

For deep dives (190-300 fsw) of short duration, or for shallower dives where nitrogen narcosis reduces mental acuity and physical dexterity, helium-oxygen diving methods will be employed.

Because of the unusual hazards incurred by long exposures to extreme environmental conditions, extended excursions away from topside support and great decompression obligations, closed-circuit diving should only be undertaken by specially trained divers. Authorization to exceed 190 fsw on air requires a CNO waiver (refer to OPNAVINST 3150.27).

For dives deeper than 300 fsw or for shallow dives where extensive in-water times are required, saturation diving is the preferred method. Disadvantages of saturation diving include the requirement for extensive logistic support and the inability of the support ship to easily shift position once the mooring is set. For this reason, it is very important that the ship be moored as closely over the work site as possible. The use of sidescan sonar, remotely operated vehicles (ROVs) or precision navigation systems will greatly aid in the successful completion of the operation.

Surface-supplied mixed-gas diving operations are discussed in Chapter Eleven. Saturation diving and saturation diving operations are discussed in Chapter Twelve. ROVs are discussed in Paragraph 10.5.3.2. Table 10-2 gives an overview of available equipment and its use.

10.5.2 Method Considerations. In mixed-gas diving, as with air diving operations, the principle factors influencing the choice of a particular method are:

- Depth and planned duration of the dive
- Availability of equipment

Table 10-2. Mixed-Gas Diving Equipment.

Type	Principal Applications	Minimum Personnel (Note 5)	Advantages	Disadvantages	Restrictions & Depth Limits
LAR V (Note 1)	Special Warfare only. Shallow search and inspection.	5	No surface bubbles. Minimum support. Long duration. Portability. Mobility	Limited to shallow depths. CNS O_2 toxicity hazards. No voice communications. Limited physical and thermal protection.	Normal: 25 fsw for 240 m. Maximum: 50 fsw for 10m. No excursion allowed when using Single Depth Diving Limits.
MK 15 (Note 1)	Special Warfare only. Search and inspection. Light repair and recovery	5	Minimum surface bubbles. Optimum gas efficiency. Portability. Mobility. Communications with ful face mask (FFM).	Extended decompression for deep dives. Limited physical and thermal protection. No voice communications (unlessFFM used) .	150 fsw, air diluent.
MK 16 (Note 1)	EOD only. Deep search and inspection.	5	Minimal surface bubbles. Optimum gas efficiency. Portability. Mobility. Non-magnetic (low mu).	Extended decompression for deep dives. Limited physical and thermal protection. No voice communications.	150 fsw, air diluent. 200 fsw, HeO2 diluent.
MK 21 MOD 1 (Note 2)	Deep search, inspection, repair, salvage and construction.	12	Horizontal mobility. Voice communications.	Support craft required. High rate of gas consumption.	Normal: 300 fsw. Maximum: 380 fsw with CNO authorization.
MK 21 MOD 0 (Note 3)	Used aboard MK 2 MOD 1 DDS. DDS search, salvage and repair. Extensive bottom time.	24 (8 per watch)	Maximum diver safety. Bottom time efficiency. Maximum comfort. Continuous personnel monitoring.	Slow deployment. Large support craft and crew. Limited mobility. MK 2 MOD 1 DDS required. High rate of gas consumption.	Diver excursion 100 feet below PTC for maximum depth of 950 fsw.
MK 22 MOD 0 (Note 3)	Standby diver for PTC.	24 (8 per watch)	Collapsable for storage in PTC.	Slow deployment. Large support craft and crew. Limited mobility. MK 2 MOD 1 DDS required. High rate of gas consumption.	Diver excursion 100 feet belop PTC for maximum depth of 950 fsw.
ROV	Deep search, inspection, photography and salvage.	Number varies with ROV.	Greater depths. No decompression required. No diver risk.	Lacks diver flexibility.	20,000 fsw.

Notes:
1. Closed-circuit UBA
2. Surface-supplied deep-sea
3. Saturation UBA
4. Minimum personnel consists of topside support and one diver in the water, with the exception of the LAR V which may have two divers

- Quantities of gas mixtures available
- Qualifications and number of personnel available
- Type of work and degree of mobility required
- Environmental considerations (i.e., temperature, visibility, type of bottom, current, pollution, etc.)
- Need for communications
- Need for special operations procedures

10.5.2.1 Depth. Depth limitations of equipment are contained in Table 10-3. These limitations are based on a number of interrelated factors such as decompression obligations, duration of gas supply and carbon dioxide absorbent material, oxygen tolerance and the possibility of nitrogen narcosis when using emergency gas (air). Divers must be prepared to work at low temperatures and for long periods of time.

Operations deeper than 300 fsw usually require Deep Diving Systems (DDSs). The decompression obligation upon the diver is of such length that in-water decompression is impractical. Use of a personnel transfer capsule (PTC) for diver transport to a deck decompression chamber (DDC) for decompression or recompression increases the margin of diver safety and support-ship flexibility.

10.5.2.2 Bottom Time Requirements. The nature of the operation may influence the bottom time requirements of the diver. An underwater search may be best undertaken by using multiple divers with short bottom times or by conducting a single bounce dive simply to identify a submerged object. Other tasks, such as underwater construction work, may require numerous dives with long bottom times requiring surface-supplied or saturation diving techniques. Although primarily intended to support deep diving operations, saturation diving systems may be ideal to support missions as shallow as 150 fsw where the nature of the work is best accomplished using several dives with extended bottom times. Under these conditions, time is saved by eliminating in-water decompression obligations for each diver and by reducing the number of dive team changes, thus compensating for the increased logistical complexity such operations entail.

10.5.2.3 Environment. Environmental conditions play an important role in planning mixed-gas diving operations. Environmental factors, such as those addressed in Volume One, Chapter Four, should be considered when planning such operations. Mixed-gas diving operations often involve prolonged dives requiring lengthy decompression and travels which carry divers great distances from a safe haven. Special attention should, therefore, be given to preventing diver hypothermia. Mixed-gas diving apparatus are designed to minimize thermal stress, but the deepest, longest helium-oxygen dives place the greatest stress on the diver. Previous dives or exposure to extreme surface conditions prior to the dive may leave the diver in a thermally compromised state. A diver who has made a previous dive or who has been exposed to adverse environmental conditions should not be considered for subsequent dives until complete rewarming of the diver has taken place, as shown by sweating, normal pulse and return of normal core temperature. Subjective thermal comfort is not an accurate indication of adequate rewarming.

Table 10-3. Equipment Operational Characteristics.

Diving Equipment	Normal Working Limit (fsw) (Notes 1 and 2)	Maximum Working Limit (fsw) (Note 1)	Chamber Requirement	Minimum Personnel
LAR V UBA	20 (Note 3)	50	None	5
MK 16 UBA	150 200	150 (air diluent) 200 (HeO_2 diluent)	None Note 9	5 5
MK 21 MOD 1 UBA	300 (HeO_2) (Note 6)	380 (HeO_2) (Notes 2,4,6)	On site	12
MK 2 MOD 1 DDS MK 21 MOD 0 UBA MK 22 MOD 0 UBA	850 (Notes 5, 6, 7) 950 (Notes 5, 6, 7, 8)	850 (Notes 5, 6, 7) 950 (Notes 5, 6, 7, 8)	Part of system	24 (8 per watch)

Notes:

1. Depth limits are based on considerations of working time, decompression obligation, oxygen tolerance and nitrogen narcosis. The expected duration of the gas supply, the expected duration of the carbon dioxide absorbent, the adequacy of thermal protection or other factors may also limit both the depth and the duration of the dive.

2. A Diving Medical Officer is required on site for all dives exceeding the normal working limit.

3. The normal depth limit for closed-circuit oxygen diving operations should be 20 fsw. The option of making an excursion to a greater depth (down to 50 fsw), if required during a dive, is acceptable and not considered "exceptional exposure". A Diving Medical Officer is not required on site for an excursion or a single-depth dive.

4. Surface-supplied helium-oxygen diving is not to exceed 300 fsw without prior CNO authorization.

5. A Diving Medical Officer is required on site for all saturation diving operations.

6. A Master Diver is required on site for alll surface-supplied mixed-gas operations.

7. A Master Diver is required on site for all saturation diving operations.

8. Normal and maximum working limits for the MK 21 MOD 0/MK 22 MOD 0 allow a maximum 100 fsw excursion deeper than the MK 2 MOD 1 DDS maximum of 850 fsw due to the extremely low risk of DCS with this excursion limit.

9. Dives deeper then 190 fsw require a recompression chamber.

must verify the qualification level of each team member.

The size and complexity of deep dive systems reinforces the need for a detailed and comprehensive watch station qualification program.

10.6.2 Diver Training. Training must be given the highest command priority. The command that dives infrequently, or with insufficient training and few workup dives between operations, will be ill-prepared in the event of an emergency. The dive team must be exercised on a regular diving schedule using both routine and nonroutine drills to remain proficient not only in the water but on topside support tasks as well. Crosstraining ensures that divers are qualified to substitute for one another if circumstances warrant.

10.6.3 Diver Fatigue. Fatigue will predispose a diver to decompression sickness. A tired diver is not mentally alert. Mixed-gas dives will not be conducted using a fatigued diver. The command must ensure that all divers making a mixed-gas dive are well rested prior to the dive. All divers making mixed-gas dives must have at least eight hours of sleep within the last 24 hours before diving.

10.7 BRIEFING THE DIVE TEAM

Large personnel requirements (Table 10-4) and the increased complexities of mixed-gas diving operations make comprehensive briefings of all personnel extremely important. For mixed-gas UBA and surface-supplied operations, briefings of each day's schedule are appropriate. In addition, during saturation diving operations, a dive protocol (Paragraph 10.9.2) is required to be read and signed in accordance with the unit's instructions.

The briefing should cover all aspects of the operation including communications, equipment, gas supply and emergencies such as fouling and entrapment. Each diving member should understand his own role as well as that of his diving companions and the support crew.

While the operation is in progress, divers returning to the surface or to the PTC should be promptly debriefed. This ensures that topside personnel are kept advised of the progress of the dive and have the information necessary to modify the dive plan or protocol as appropriate.

10.8 FINAL PREPARATIONS AND SAFETY PRECAUTIONS

Prior to the start of a mixed-gas diving operation, it is important to check that all necessary preparations have been made and that all safety precautions have been checked. This ensures that the diving team is properly supported in its mission and that all possible contingencies have been evaluated in case an unexpected circumstance should arise.

10.9 RECORD KEEPING

Volume One, Appendix G, describes the objectives and importance of maintaining accurate records. The Diving Officer, Master Diver and Diving Supervisor should identify those records required for their respective systems and tailor them to suit their needs. The purpose of any record is to provide an accurate and detailed account of every facet of the diving operation and a tabulation of supplies expended to support the operation (e.g., gases, carbon dioxide absorbent, etc.). Any unusual circumstances regarding dive conduct (i.e., treatments, operational/emergency procedures, or deviation from procedures) established in the *U. S. Navy Diving Manua*l shall be brought to the attention of the Commanding Officer and logged in the Command Smooth Diving Log.

Table 10-4. Personnel Requirements Chart for Mixed-Gas Diving.

Mixed-Gas UBA Dive Team				
	Optimum		Minimum	
Designation	**One Diver**	**Two Divers**	**One Diver**	**Two Divers**
Diving Officer	1 (Notes 3,4)	1 (Notes 3,4)	1 (Notes 3,4)	1 (Notes 3,4)
Diving Medical Officer	Note 6	Note 6	Note 6	Note 6
Diving Supervisor	1	1	1 (Note 2)	1 (Note 2)
Diver	1	2	1	2
Standby Diver	1 (Note 10)	1 (Note 10)	1 (Note 10)	1 (Note 10)
Tender	1 (Note 1)	2 (Note 1)	1 (Note 1)	1 (Note 1)
Timekeeper/Recorder	1	1		
EBS Operator	Note 7	Note 7	Note 7	Note 7
Total Personnel Required	6	8	5	5

Surface-Supplied Mixed-Gas Dive Team

	Deep-Sea (MK 21)	
Designation	**One Diver**	**Two Divers**
Diving Officer	1 (Note 14)	1 (Note 14)
Diving Medical Officer	(Notes 6 and 14)	(Notes 6 and 14)
Diving Supervisor/Master Diver	1 (Notes 11 and 14)	1 (Notes 11 and 14)
Diving Medical Technician	1 (Notes 8 and 14)	1 (Notes 8 and 14)
Diver	1	2
Standby Diver	1	1
Tender	3	5
Timekeeper/Recorder	1 (Note 14)	1 (Note 14)
Rack Operator	1	1
Winch/Tugger Operator	1 (Note 5)	1 (Note 5)
Console Operator	1 (Note 14)	1 (Note 14)
Total Personnel Required	12	15

Table 10-4. Personnel Requirements Chart for Mixed-Gas Diving - Continued.

Deep Diving System DDS MK 2 MOD 1 Dive Team	
Watch Station	**NOBC/NEC (Note 12)**
Diving Officer	9315, 5346
Diving Medical Officer	0107
Master Diver	5346
Diving Supervisor	5311, 5346
Atmosphere Monitor	5346, 5311, 8493, 8494
MCC Gas-Control Operator	5311, 5342, 5346, 8493, 8494
Life-Support Operator	5311, 5342, 8493, 5346, 8494
MCC Communications and Log Operator	5311, 5342, 8493, 5343, 5346, 8494
Surface-Support Divers	5311, 5342, 8493, 5343, 5346, 8494
Gas King	5346, 5311, 8493, 5342, 8494
PTC Operators	9315, 5346, 5311, 8493, 8494
PTC Divers	9315, 5346, 5311, 8493, 8494
Main Deck Supervisor	5346, 5311, 5342

Table 10-4. Personnel Requirements Chart for Mixed-Gas Diving - Continued.

Notes:

1. One tender per diver when divers are surface tended. If using a buddy line, one tender is required for each buddy pair.

2. May act as timekeeper/recorder.

3. EOD Diving Officer is required on site for all EOD operations; for SPECWAR, Diving Officer is not required on site.

4. Diving Officer may perform any other function simultaneously (i.e., Diving Officer/Diver).

5. Ascent/descent control of stage.

6. A Diving Medical Officer is required on site for all dives exceeding the normal working limit.

7. EBS operator is for MK 16 in-water decompression dives.

8. Diving Medical Technician required when no Diving Medical Officer is available.

9. Single diver must be tethered; EOD may use a witness buoy in lieu of a tether. when conducting live ordnance operations, the use of a tending line and witness buoy may be omitted at the discretion of the EOD Diving Officer.

10. Standby diver will be fully dressed with the exception of SCUBA or MK 16, mask and fins. These items will be ready to don.

11. Master Diver must be on site for all saturation and surface-supplied mixed-gas diving operations, and may serve as the Diving Officer if so designated in writing by the Commanding Officer.

12. The NECs listed are the minimum level qualifications allowed. The surface-support divers must be qualified in the diving method being used. NOBC 9315 and NEC 5346 can stand any watch for which qualified except Diving Medical Officer. NEC 5311 can qualify to stand Dive Watch Supervisor. Manning is shown for use of one DDC only. Additional handling crew for the PTC is required from ship's personnel, but the PTC handling crew is not shown on the chart.

13. A Diving Medical Officer is required on-site for all saturation diving operations.

14. Provided sufficient numbers of formally trained and qualified mixed-gas divers are assigned to dive station in positions critical to the safe conduct of a mixed-gas dive, assigned divers need only meet minimum qualifications as surface-supplied divers. To ensure sufficient properly trained and qualified individuals are assigned to the most critical positions on a surface-supplied mixed-gas dive station, the following minimum stations will be manned by formally trained mixed-gas divers:

Diving Officer
Diving Medical Officer (Note 6)
Master Diver
Diving Supervisor
Diving Medical Technician
Time Keeper - Recorder
Console Operator

All Other assignments to a surface-supplied mixed-gas dive station may be filled by any surface-supplied qualified U.S. Navy Diver.

10.10.1 MK 15 UBA Description

Principle of Operation

Self-contained closed-circuit constant ppO_2 system

Minimum Equipment

MK IV Life Jacket with four 31-gram CO_2 cartridges

Dive knife

Swim fins

Face mask or full face mask (FFM)

Weight belt (as required)

Dive watch

Depth gauge

Emergency flare (open water)

Compass

Whistle

Principal Applications

Special warfare operations only

Search and inspection

Light repair and recovery

Advantages

Minimal surface bubbles

Optimum efficiency of gas supply

Portability

Excellent mobility

Communications (when used with FFM)

Modularized assembly

Disadvantages

Extended decompression requirement for dives deeper than 77 feet

Limited physical and thermal protection

No voice communications (unless FFM used)

Restrictions

Working limit 150 feet, air diluent

Operational Considerations

Dive team (Table 10-4)

One safety boat required (refer to Paragraph 13.4.2).

MK 15 decompression schedule must be used (unless using CSMD procedure 70 fsw and shallower, or air decompression procedures 70 fsw and shallower).

Figure 10-2. MK 15 UBA.

10.10.2 MK 16 UBA Description

Principle of Operation

Self-contained closed-circuit constant ppO_2 system

Minimum Equipment

MK IV Life Jacket with four 31-gram CO_2 cartridges

Dive knife

Emergency flare (open water)

Swim fins

Face mask

Weight belt (as required)

Dive watch

Depth gauge

Principal Applications

EOD operations only

Deep Search and inspection

Advantages

Minimal surface bubbles

Optimum efficiency of gas supply

Portability

Excellent mobility

Modularized assembly

Nonmagnetic (low mu)

Disadvantages

Extended decompression for long bottom times or deep dives

Limited physical and thermal protection

No voice communications

Restrictions

Working limit 150 feet, air diluent

Working Limit 200 feet, HeO_2 diluent

Operational Considerations

Diveing team (Table 10-4)

Safety boat required (refer to Paragraph 13.4.2).

Decompression schedule to be carried.

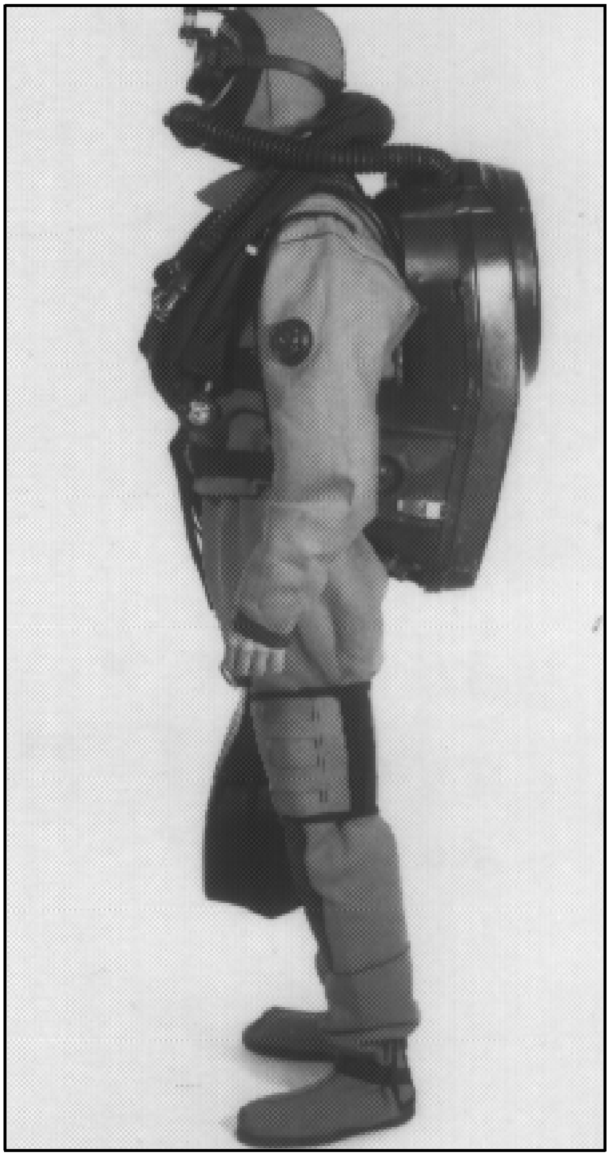

Figure 10-3. MK 16 UBA.

CHAPTER ELEVEN

SURFACE SUPPLIED MIXED GAS DIVING OPERATIONS

11.1 INTRODUCTION

Surface supplied mixed gas diving is conducted with helium oxygen mixtures supplied from the surface by a flexible hose (Figures 11 1a and 11 1b). Surface supplied mixed gas diving is particularly suited for operations beyond the depth limits of air diving, yet short of the depths and times requiring the use of a deep diving system. Surface supplied mixed gas diving is also useful in the deep air diving range when freedom from nitrogen narcosis is required. Mixed gas diving theory is discussed in Appendix A.

11.2 PLANNING THE OPERATION

Planning surface supplied mixed gas dives is similar to planning air dives and involves many of the same considerations. Planning aspects that are unique to surface supplied mixed gas diving include the logistics of providing several different gas mixtures to the diver, and the limitations on the duration of carbon dioxide absorption canisters in cold water.

11.2.1 Depth and Exposure Time. The normal operational limit for surface supplied mixed gas diving is 300 fsw. Within each decompression table, exceptional exposure dives are enclosed in red boxes to separate them from normal working dives. Exceptional exposure dives require lengthy decompression and are associated with an increased risk of decompression sickness and exposure to the elements. Exceptional exposures should be undertaken only in emergency circumstances. Planned exceptional exposure dives require prior CNO approval. Repetitive diving is not allowed in surface supplied helium oxygen diving.

11.2.2 Water Temperature. Loss of body temperature (hypothermia) can be a major problem during long, deep dives. Because the high thermal conductivity of helium in a dry suit accelerates the loss of body heat, a hot water suit is preferred for surface supplied dives when using the MK 21 MOD 1 in very cold water.

Thermal problems are discussed and the signs and symptoms of decreasing body temperature (hypothermia) are listed in Volume One, Chapter Eight, of this manual. The most important thermal problem of surface supplied mixed gas diving using a dry suit is loss of body heat as a result of the high thermal conductivity of helium.

11.2.3 Gas Mixtures. Air, 100 percent oxygen, and several helium oxygen mixtures will be required to dive the surface supplied mixed gas tables over their full range. The logistics of supplying these gases must be carefully planned. Analysis of the oxygen content of helium oxygen mixtures shall be accurate to within ±0.5 percent.

For each depth in the decompression tables, the allowable maximum and minimum oxygen percentage in the helium oxygen mixture used on the bottom is specified. For operations planning, the range of possible depths should be established and a mixture selected that will meet the maximum/minimum specification across the depth range. The maximum oxygen concentration has been selected so that the diver never exceeds an oxygen

Figure 11-1b. MK 21 MOD 1 Lightweight Surface-Supplied Mixed-Gas Diving System.

partial pressure of 1.3 ata while on the bottom. The minimum oxygen percentage allowed in the mixture is 16 percent for depths to 200 fsw, 12 percent for depths from 200 fsw to 300 fsw, and 10 percent for depths in excess of 300 fsw. Diving with a mixture near maximum oxygen percentage is encouraged as it offers a decompression advantage to the diver.

On the surface, the diver's gas mixture must contain a minimum of 16 percent oxygen. When a bottom mix with less than 16 percent oxygen is to be used, a shift to the bottom mix is made at 20 fsw during descent (see Paragraph 11.3.1).

For dives deeper than 200 fsw in which the bottom mixture contains less than 16 percent oxygen, a gas shift from the bottom mix to a 60 percent helium/40 percent oxygen mixture is required at the 100 fsw decompression stop or the next shallower stop if there is no 100 fsw stop (see Paragraph 11.3.2). For dives to 200 fsw and shallower or for deeper dives in which the bottom mixture contains more than 16 percent oxygen, a shift to 60 percent helium/40 percent oxygen is not required but can be executed to increase decompression safety if desired. For exceptional exposure dives, a shift to a 60 percent helium/40 percent oxygen mixture is highly desirable.

On all dives, a shift to 100 percent oxygen is made at the 50 fsw or 40 fsw water stop.

All divers are equipped with an emergency gas supply (EGS). The EGS gas mixture will be the same as the bottom mixture unless the bottom mixture contains less than 16 percent oxygen, in which case the EGS gas mixture will be 16 ±0.5 percent oxygen and the balance will be helium.

11.3 SURFACE SUPPLIED HELIUM OXYGEN COMPRESSION AND DECOMPRESSION PROCEDURES

The Surface Supplied Helium Oxygen Decompression Table (Table 11 4) is used to decompress divers from surface supplied helium oxygen dives. The table is in a depth time format similar to the USN Air Decompression Table and is used in a similar fashion. One additional table, the Emergency Procedures Decompression Table (Table 11 1) is used under emergency conditions (Paragraph 11.4.4).

Table 11-1. Emergency Procedures Decompression Table.

Decompression Stop Depth (fsw)	Decompression Stop Time (min)
50	30
40	35
30	42
20	52
10	68

The Surface Supplied Helium Oxygen Decompression Table specifies the maximum and minimum concentrations of oxygen allowable in the helium oxygen mixture at depth. Select a gas mixture for the dive that is compatible with the deepest depth anticipated for the dive. To select the proper decompression table and schedule, measure the deepest depth reached by the diver and enter the table at the exact or next greater depth. When using an air filled pneumofathometer to measure depth, the observed depth readings must be corrected as shown in Table 11 2. It is also important that the pneumofathometer be at mid chest level. The bottom time is measured as the time from leaving the surface to leaving the bottom, rounded up to the next whole minute, except as noted in Paragraph 11.3.1. Enter the table at the exact or next greater bottom time.

Table 11-2. Pneumofathometer Correction Factors.

Pneumofathometer Depth	Correction Factor
0-100 fsw	+ 1 fsw
101-200 fsw	+ 2 fsw
201-300 fsw	+ 4 fsw
301-400 fsw	+ 7 fsw

> **Example:** The diver's pneumofathometer reads 250 fsw. In the depth range of 201 300 fsw, the pneumofathometer underestimates the diver's true depth by 4 fsw. To determine the true depth, 4 fsw must be added to the pneumofathometer reading. The diver's true depth is 254 fsw.

The compression rate is not critical, but it should not exceed 120 fsw/min. Decompression is at a constant rate of 30 fsw/minute. The decompression time between stops is included in the time of the subsequent stop, except when the shift to 100 percent oxygen is made.

For dives as deep as 200 fsw, decompression is taken on the bottom mixture up to the 50 fsw water stop (40 fsw if 40 fsw is the first stop) and the diver is then shifted to 100 percent oxygen. For dives greater than 200 fsw, decompression is taken on the bottom mixture to the 100 fsw water stop (or next shallower stop if there is no 100 fsw stop) and the diver is then shifted to a 60 percent helium/40 percent oxygen mixture. Upon arrival at the 50 fsw water stop, the diver is shifted to 100 percent oxygen. Surface decompression may be taken after completion of a portion of the 40 fsw oxygen stop on all dives, as described in Paragraphs 11.3.5.1 and 11.3.5.2.

11.3.1 Special Procedures for Descent with Less Than 16 Percent Oxygen. To avoid hypoxia, a special descent procedure is required whenever the bottom mixture contains less than 16 percent oxygen. Place the diver on the surface on air. After appropriate predive checks have been made, have the diver descend to 20 fsw while breathing air. At 20 fsw, shift the diver to the bottom mix and ventilate. When the diver is confirmed to be on the bottom mix, perform a final leak check and have the diver begin descent.

The diver is allowed ten minutes at 20 fsw to shift to the bottom mixture and perform equipment checks. The bottom time starts when the diver leaves 20 fsw. If more than ten minutes must be spent at 20 fsw, the bottom time is begun at the ten minute mark. The time from leaving the surface to leaving 20 fsw should be noted on the diving chart in case the dive must be aborted during descent (Paragraph 11.3.6).

If it is necessary to bring the diver back to the surface from 20 fsw, shift the diver back to air, ventilate the diver, and confirm that the diver is on air prior to ascent. When the diver reenters the water the ten minute period begins again.

11.3.2 Procedures For Shifting To 60 Percent Helium/40 Percent Oxygen At 100 fsw. For dives deeper than 200 fsw in which the bottom mixture contains less than 16 percent oxygen, it is necessary to shift from the bottom mixture to 60 percent helium/40 percent oxygen at 100 fsw during decompression or the next shallower stop if there is no 100 fsw decompression stop. Ventilate each MK 21 MOD 1 diver with 16 scf of the mixture. The time required to effect the shift over to 40 percent oxygen is not critical.

Shifting procedures are contained in system OPs and EPs.

11.3.3 Procedures For Shifting to 100 Percent Oxygen at the First Oxygen Stop. All dives except no decompression dives require a shift to 100 percent oxygen at the 50 fsw stop, or at the 40 fsw stop if there is no 50 fsw stop. Upon arrival at the stop, ventilate each MK 21 MOD 1 diver with 10 scf of oxygen. Time at the stop begins when the diver is confirmed to be on oxygen. When 50 fsw is the first oxygen stop, the ascent time from 50 fsw to 40 fsw is included in the time of the 40 fsw stop.

To compute the pressure drop in a bank of oxygen that will result in the required ventilation rate, the following formula may be used:

$$\Delta P = \frac{SCF}{FV \times N} \times 14.7$$

Where:

ΔP	=	pressure drop in psig
SCF	=	desired ventilation volume in scf
FV	=	floodable volume of one cylinder in the bank in cu. ft.
N	=	number of cylinders on line in the bank

Example: Determine the pressure drop required in two K bottles of oxygen to produce a 25 scf vent.

$$\Delta P = \frac{25}{1.63 \times 2} \times 14.7 = 113 \text{ psig}$$

11.3.4 Ascent from the 40 fsw Water Stop. For normal in water decompression, the diver surfaces from 40 fsw during the last minute of the 40 fsw stop. Ascent rate is 40 fsw/min. For example, if the 40 fsw stop is 68 minutes, the diver remains at 40 fsw for 67 minutes. During the last minute, he travels to the surface at 40 fsw/minute. A normal in water decompression dive profile is shown in Figure 11 2.

11.3.5 Surface Decompression Procedures (SUR D). There are two types of surface decompression procedures, Normal SUR D and Emergency SUR D. Normal SUR D procedures are preferred over in water decompression procedures in routine operations. Normal SUR D procedures improve the diver's comfort and safety but increase total decompression time and oxygen consumption. Emergency SUR Ds are used for handling CNS oxygen toxicity symptoms, systems failures, and other emergency conditions. Emergency surface decompression allows the diver to be removed from the water in the shortest possible time.

11.3.5.1 Normal SUR D Procedures Using Oxygen. A diver is eligible for normal surface decompression if he has been on oxygen at 40 fsw for a length of time equal to that of the 50 fsw stop. If there is no 50 fsw stop, ten minutes on oxygen at 40 fsw is required.

Example: If the 50 fsw stop time is 12 minutes, the diver must remain on oxygen at 40 fsw for 12 minutes before normal surface decompression can be implemented.

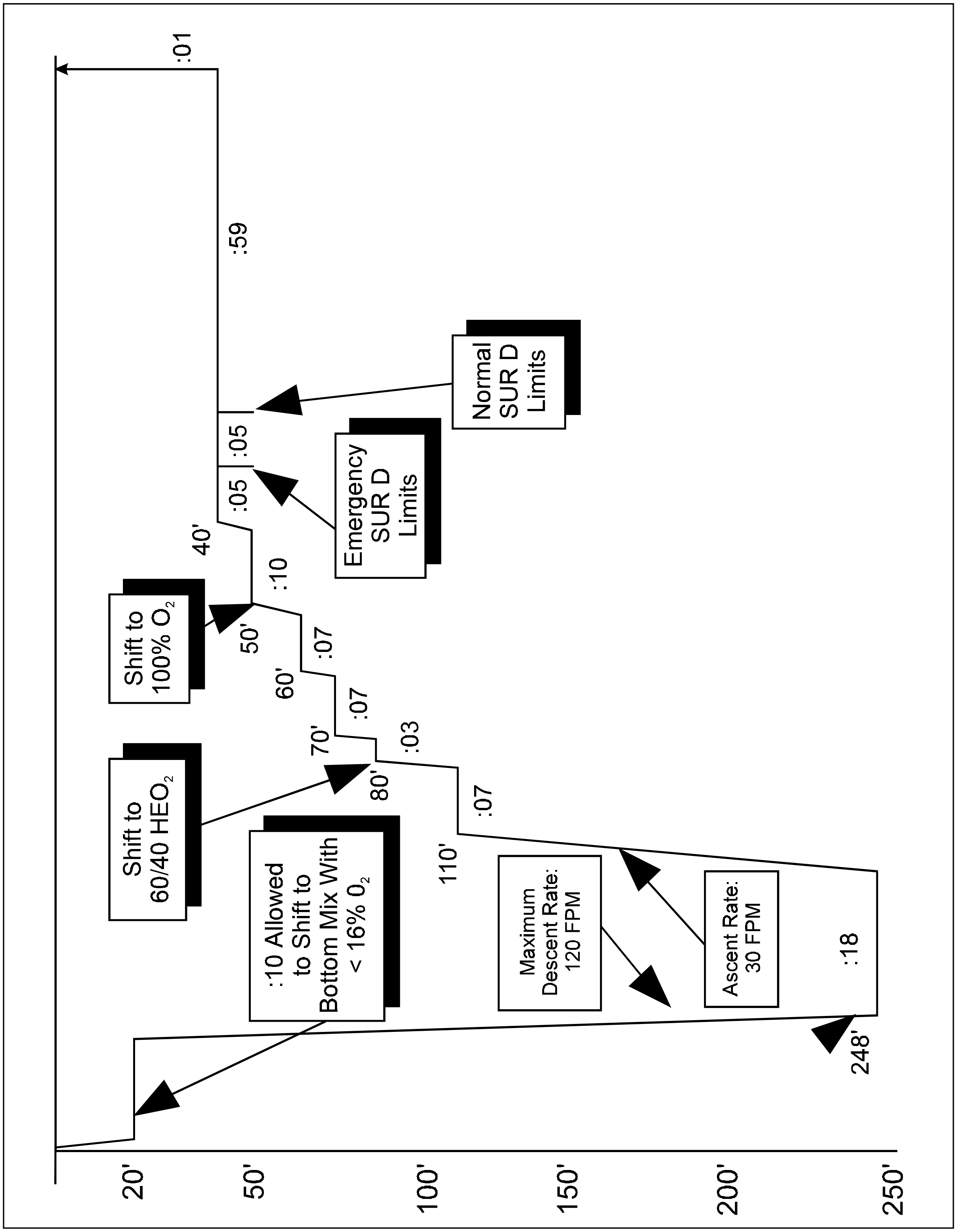

Figure 11-2. Normal In-Water Decompression Dive Profile for a 248 fsw/:18 Dive.

Delays up to five minutes in leaving the 50 fsw and 40 fsw oxygen stops may be ignored. Longer delays may be associated with an increased risk of oxygen toxicity and should be avoided.

Disregard any delays in travel from 40 feet to the surface during surface decompression unless the diver exceeds the five minute interval, in which case the diver shall be treated for omitted decompression (see Paragraph 11.4.10).

11.3.8 Special Procedures for Diving with An Oxygen Partial Pressure Greater Than 1.3 ata. Limited gas supplies or system constraints may force some surface supplied helium oxygen dives to be performed at oxygen partial pressures greater than 1.3 ata. Such dives place the diver at increased risk for CNS oxygen toxicity on the bottom and require NAVSEA concurrence and CNO approval. Bottom times shall be limited to those shown in Table 11 3.

Table 11-3. Oxygen Partial Pressure Exposure Limits for Surface-Supplied HeO_2 Diving.

Oxygen Partial Pressure (ata)	Maximum Bottom Time (min)
1.80	15
1.70	20
1.60	30
1.50	40
1.40	50
1.30	Unlimited

Oxygen partial pressure is calculated using the following formula:

$$ppO_2 = \frac{\%O_2}{100} \times \frac{D + 33}{33}$$

where: ppO_2 = oxygen partial pressure in ata
$\% O_2$ = Oxygen percentage in the mixture
D = Diver's depth in fsw

Example: A diver is at 250 fsw breathing a 17.0% oxygen mixture. The oxygen partial pressure is:

$$ppO_2 = \frac{17}{100} \times \frac{250 + 33}{33} = 1.46 \text{ ata}$$

To dive in accordance with this section, determine the bottom time that will be required to complete the task. From Table 11 3, select the oxygen partial pressure that corresponds to this bottom time. If the bottom time is not exactly equal to the times listed in the Table, round to the next longer bottom time. Determine the deepest depth that will be attained by the diver during the dive. Rearrange the oxygen partial pressure equation to solve for the maximum oxygen percentage that can be used:

$$\%O_2 = \frac{ppO_2 \times 33}{D + 33} \times 100$$

Example: A dive to a maximum depth of 270 fsw will require 35 minutes of bottom time. What is the maximum oxygen percentage that can be used for this dive? Round the 35 minute bottom time to 40 minutes, the next longer bottom time given in Table 11 4. The maximum allowable oxygen partial pressure for this bottom time is 1.50 ata. Solve the above equation for a ppO2 = 1.50 ata and D = 270 fsw.

$$\%O_2 = \frac{1.50 \times 33}{270 + 33} \times 100 = 16.34$$

Any gas mixture between the calculated maximum value and the maximum value shown in the decompression table may be used to make the dive under the provisions of this section.

11.3.9 Charting Surface Supplied Helium Oxygen Dives. Figure 11-5 provides the proper format for charting surface supplied helium oxygen dives.

11.4 SURFACE SUPPLIED HELIUM OXYGEN EMERGENCY PROCEDURES

In surface supplied mixed gas diving, specific procedures are used in emergency situations. The following paragraphs detail these procedures. Other medical/physiological factors that surface supplied mixed gas divers need to consider are covered in detail in Volume One, Chapters Three and Eight. The USN Treatment Tables are also presented in Chapter Eight.

11.4.1 Bottom Time in Excess of the Table. In the rare instance of diver entrapment or umbilical fouling, bottom times may exceed 120 minutes, the longest value shown in the table. If this situation occurs, advice on the decompression procedure to follow should be sought immediately from the Navy Experimental Diving Unit or the Naval Medical Research Institute. If advice cannot be obtained in time, decompress the diver using the 120 minute schedule for the deepest depth attained. Surface the diver after completing 30 minutes on oxygen at 40 fsw. Quickly recompress the diver to 60 fsw in the chamber and treat on Treatment Table 6.

11.4.2 Loss of Helium Oxygen Supply on the Bottom. In the event that the umbilical helium oxygen supply is lost on the bottom, shift the diver to the emergency gas system (EGS). Unless the loss is momentary, abort the dive. Remain on the EGS until arrival at the first water stop. If the first water stop is an oxygen stop, shift to oxygen and complete the decompression. If the first stop is a helium oxygen stop shallower than 160 fsw, shift to air at the first stop and continue on the original decompression schedule to 50 fsw. If 60 percent helium/40 percent oxygen is available, upon reaching 100 fsw shift the divers to this mixture and continue on the original decompression schedule to 50 fsw. Shift to oxygen at 50 fsw and complete the decompression. If the first stop is 160 fsw or deeper, delay the air shift to 150 fsw. If the EGS becomes exhausted before the first stop can be reached, shift the diver to air, ascend to the first stop, and continue as outlined above.

11.4.3 Inability to Shift to 40 Percent Oxygen at 100 fsw During Decompression. In the event that the diver cannot be shifted to 60 percent helium/40 percent oxygen at 100 fsw during decompression, shift the diver to air. Follow the stops of the original decompression schedule to 50 fsw. Shift to oxygen at 50 fsw and complete the decompression as originally planned.

11.4.4 Loss of Oxygen Supply at 50 fsw. In the event that the diver cannot be shifted to oxygen at 50 fsw or the oxygen supply is lost during the 50 fsw stop, take the following action. If 60 percent helium/40 percent oxygen is available on the console, shift the diver to that mixture. If 60 percent helium/40 percent oxygen is not available, shift the diver to air and go on open circuit. If the problem can be remedied quickly, reventilate the diver with oxygen and resume the schedule at the point of interruption. Consider any time on air or helium oxygen as dead time. If the

Table 11-4. Surface-Supplied Helium Oxygen Decompression Table - Continued.

Depth (fsw)	Bottom Time (min.)	Time to First Stop (min:sec)	Decompression Stops (fsw)																Total Ascent Time* (min:sec)
			190	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	
			Bottom Mix														100% O_2		
110	10	2:20																16	18:20
Max O_2 = 30.0%	20	2:20																29	31:20
Min O_2 = 16.0%	30	2:20																42	44:20
	40	2:20																53	55:20
	60	2:20																73	75:20
	80	2:20																86	88:20
	100	2:20																92	94:20
	120	2:20																96	98:20
120	10	2:40																19	21:40
Max O_2 = 28.0%	20	2:40																34	36:40
Min O_2 = 16.0%	30	2:40																49	51:40
	40	2:40																62	64:40
	60	2:40																82	84:40
	80	2:40																94	96:40
	100	2:40																99	101:40
	120	2:20															10	97	109:20
130	10	2:40															10	11	23:40
Max O_2 = 26.3%	20	2:40															10	28	40:40
Min O_2 = 16.0%	30	2:40															10	45	57:40
	40	2:20														7	10	59	78:20
	60	2:20														7	10	78	97:20
	80	2:20														7	10	90	109:20
	100	2:20														7	10	96	115:20
	120	2:20														7	11	98	118:20
140	10	3:00															10	11	24:00
Max O_2 = 24.8%	20	3:00															10	28	41:00
Min O_2 = 16.0%	30	3:00															10	45	58:00
	40	2:40														7	10	59	78:40
	60	2:40														7	10	78	97:40
	80	2:40														7	10	90	109:40
	100	2:40														7	10	96	115:40
	120	2:40														7	11	98	118:40
150	10	3:20															10	12	25:20
Max O_2 = 23.4%	20	3:00														7	10	33	53:00
Min O_2 = 16.0%	30	3:00														7	10	50	70:00
	40	3:00														7	10	65	85:00
	60	3:00														7	10	84	104:00
	80	3:00														7	10	96	116:00
	100	3:00														7	13	99	122:00
	120	3:00														7	16	99	127:00

* Does not include oxygen shiftover time

Table 11-4. Surface-Supplied Helium Oxygen Decompression Table - Continued.

Depth (fsw)	Bottom Time (min.)	Time to First Stop (min:sec)	190	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	Total Ascent Time* (min:sec)
			Bottom Mix														100% O_2		
160	10	3:20														7	10	15	35:20
Max O_2 = 22.2%	20	3:20														7	10	36	56:20
Min O_2 = 16.0%	30	3:20														7	10	55	75:20
	40	3:20														7	10	70	90:20
	60	3:00													7	6	10	83	109:00
	80	3:00													7	9	10	98	127:00
	100	3:00													7	13	14	98	135:00
	120	3:00													7	17	16	99	142:00
170	10	3:20													7	0	10	17	37:20
Max O_2 = 21.1%	20	3:20													7	0	10	41	61:20
Min O_2 = 16.0%	30	3:20													7	1	10	62	83:20
	40	3:20													7	4	10	77	101:20
	60	3:20													7	10	10	92	122:20
	80	3:20													9	14	13	98	137:20
	100	3:00												7	5	18	15	99	147:00
	120	3:00												7	9	21	16	99	155:00
180	10	3:40													7	0	10	20	40:40
Max O_2 = 20.1%	20	3:40													7	0	10	44	64:40
Min O_2 = 16.0%	30	3:40													7	4	10	67	91:40
	40	3:20												7	0	8	10	81	109:20
	60	3:20												7	5	11	10	96	132:20
	80	3:20												7	9	15	15	99	148:20
	100	3:20												7	13	19	16	99	157:20
	120	3:20												7	17	23	16	99	165:20
190	10	4:00													7	0	10	22	43:00
Max O_2 = 19.2%	20	3:40												7	0	2	10	50	72:40
Min O_2 = 16.0%	30	3:40												7	0	7	10	69	96:40
	40	3:40												7	4	9	10	84	117:40
	60	3:40												7	9	13	12	93	137:40
	80	3:20											7	3	13	18	15	99	158:20
	100	3:20											7	6	16	21	16	99	168:20
	120	3:20											7	8	20	23	16	99	176:20
200	10	4:00												7	0	0	10	25	46:00
Max O_2 = 18.4%	20	4:00												7	0	4	10	53	78:00
Min O_2 = 16.0%	30	3:40											7	0	3	7	10	74	104:40
	40	3:40											7	0	7	10	10	86	123:40
	60	3:40											7	4	10	14	13	98	149:40
	80	3:40											7	8	14	18	16	99	165:40
	100	3:40											7	12	17	23	16	99	177:40
	120	3:40											8	15	21	23	16	99	185:40

* Does not include oxygen shiftover time

Table 11-4. Surface-Supplied Helium Oxygen Decompression Table - Continued.

Depth (fsw)	Bottom Time (min.)	Time to First Stop (min:sec)	Decompression Stops (fsw)																Total Ascent Time* (min:sec)
			190	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	
			Bottom Mix									40% O_2					100% O_2		
210 Max O_2 = 17.7% Min O_2 = 12.0%	10	4:20												7	0	0	10	28	49:20
	20	4:00											7	0	1	6	10	57	85:00
	30	4:00											7	0	6	7	10	79	113:00
	40	4:00											7	3	9	10	10	90	133:00
	60	3:40										7	0	9	11	17	13	98	158:40
	80	3:40										7	3	11	15	20	13	99	171:40
	100	3:40										7	6	14	19	23	16	99	187:40
	120	3:40										7	8	18	23	23	16	99	197:40
220 Max O_2 = 17.0% Min O_2 = 12.0%	10	4:40												7	0	2	10	30	53:40
	20	4:20											7	0	3	7	10	61	92:20
	30	4:20											7	2	6	9	10	81	119:20
	40	4:00										7	0	6	9	11	10	93	140:00
	60	4:00										7	4	9	12	18	14	99	167:00
	80	4:00										7	8	12	17	21	16	99	184:00
	100	4:00										7	12	15	20	23	16	99	196:00
	120	4:00										8	14	19	23	23	16	99	206:00
230 Max O_2 = 16.3% Min O_2 = 12.0%	10	4:40											7	0	0	3	10	33	57:40
	20	4:20										7	0	1	4	7	10	65	98:20
	30	4:20										7	0	5	7	10	10	85	128:20
	40	4:00									7	0	3	7	9	13	11	95	149:00
	60	4:00									7	0	8	10	14	18	15	99	175:00
	80	4:00									7	3	10	14	18	23	16	99	194:00
	100	4:00									7	6	12	17	23	23	16	99	207:00
	120	4:00									7	7	16	19	23	23	16	99	214:00
240 Max O_2 = 15.7% Min O_2 = 12.0%	10	4:40										7	0	0	2	4	10	35	62:40
	20	4:40										7	0	2	5	7	10	68	103:40
	30	4:20									7	0	2	6	7	10	10	87	133:20
	40	4:20									7	0	5	8	9	14	12	96	155:20
	60	4:20									7	4	8	11	14	19	16	99	182:20
	80	4:20									7	7	11	16	18	23	16	99	201:20
	100	4:20									7	10	14	19	23	23	16	99	215:20
	120	4:00								7	3	12	17	19	23	23	16	99	223:00
250 Max O_2 = 15.2% Min O_2 = 12.0%	10	5:00										7	0	0	2	4	10	37	65:00
	20	4:40									7	0	0	3	7	7	10	70	108:40
	30	4:40									7	0	4	6	8	10	10	89	138:40
	40	4:40									7	2	5	9	9	14	13	96	159:40
	60	4:20								7	0	7	9	12	16	21	16	99	191:20
	80	4:20								7	3	9	13	15	21	23	16	99	210:20
	100	4:20								7	6	11	14	19	23	23	16	99	222:20
	120	4:20								7	8	13	19	20	23	23	16	99	232:20

* Does not include oxygen shiftover time

Table 11-4. Surface-Supplied Helium Oxygen Decompression Table - Continued.

Depth (fsw)	Bottom Time (min.)	Time to First Stop (min:sec)	190	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	Total Ascent Time* (min:sec)
			Bottom Mix									40% O_2					100% O_2		
260	10	5:00									7	0	0	0	4	4	10	40	70:00
Max O_2 = 14.6%	20	5:00									7	0	2	4	6	7	10	74	115:00
Min O_2 = 12.0%	30	4:40								7	0	2	5	6	9	10	10	92	145:40
	40	4:40								7	0	3	8	9	10	15	14	96	166:40
	60	4:40								7	3	7	10	14	16	21	16	99	197:40
	80	4:40								7	6	10	13	17	23	23	16	99	218:40
	100	4:20							7	2	9	13	16	20	23	23	16	99	232:20
	120	4:20							7	4	11	14	19	20	23	23	16	99	240:20
270	10	5:20									7	0	0	2	3	4	10	42	73:20
Max O_2 = 14.2%	20	5:00								7	0	0	2	6	6	8	10	78	122:00
Min O_2 = 12.0%	30	5:00								7	0	3	6	6	9	13	10	93	152:00
	40	4:40							7	0	2	5	8	8	12	16	13	98	173:40
	60	4:40							7	0	6	8	10	14	19	23	16	99	206:40
	80	4:40							7	3	8	11	14	17	23	23	16	99	225:40
	100	4:40							7	5	11	13	16	20	23	23	16	99	237:40
	120	4:40							7	8	12	16	19	20	23	23	16	99	247:40
280	10	5:40									7	0	0	3	3	4	10	46	78:40
Max O_2 = 13.7%	20	5:20								7	0	0	4	6	7	7	10	81	127:20
Min O_2 = 12.0%	30	5:00							7	0	1	5	5	9	9	12	10	96	159:00
	40	5:00							7	0	4	6	8	9	12	17	15	98	181:00
	60	5:00							7	4	6	8	12	15	18	23	16	99	213:00
	80	4:40						7	0	7	9	11	15	17	23	23	16	99	231:40
	100	4:40						7	2	9	11	15	17	20	23	23	16	99	246:40
	120	4:40						7	4	11	13	16	19	20	23	23	16	99	255:40
290	10	5:40								7	0	0	0	4	3	4	10	49	82:40
Max O_2 = 13.3%	20	5:20							7	0	0	2	6	6	6	9	10	83	134:20
Min O_2 = 12.0%	30	5:20							7	0	2	5	5	9	9	14	12	94	162:20
	40	5:20							7	0	5	7	8	11	13	17	15	98	186:20
	60	5:00						7	0	6	7	9	12	15	20	23	16	99	219:00
	80	5:00						7	2	8	10	12	16	19	23	23	16	99	240:00
	100	5:00						7	5	10	12	15	19	20	23	23	16	99	254:00
	120	5:00						7	8	11	16	17	19	20	23	23	16	99	264:00
300	10	6:00								7	0	0	0	4	3	4	10	49	83:00
Max O_2 = 12.9%	20	5:40							7	0	0	2	6	6	6	9	10	83	134:40
Min O_2 = 12.0%	30	5:40							7	0	2	5	5	9	9	14	12	94	162:40
	40	5:40							7	0	5	7	8	11	13	17	15	98	186:40
	60	5:20						7	0	6	7	9	12	15	20	23	16	99	219:20
	80	5:20						7	2	8	10	12	16	19	23	23	16	99	240:20
	100	5:20						7	5	10	12	15	19	20	23	23	16	99	254:20
	120	5:20						7	8	11	16	17	19	20	23	23	16	99	264:20

* Does not include oxygen shiftover time

Table 11-4. Surface-Supplied Helium Oxygen Decompression Table - Continued.

Depth (fsw)	Bottom Time (min.)	Time to First Stop (min:sec)	Decompression Stops (fsw) 190	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	Total Ascent Time* (min:sec)
			Bottom Mix									40% O_2					100% O_2		
310	10	6:00							7	0	0	0	3	3	3	7	10	54	93:00
Max O_2 = 12.5%	20	5:40						7	0	0	2	4	5	6	7	10	10	85	141:40
Min O_2 = 10.0%	30	5:40						7	0	2	4	5	7	8	11	15	13	98	175:40
	40	5:20					7	0	1	4	6	7	8	12	15	19	16	99	199:20
	60	5:20					7	0	5	6	9	11	13	17	20	23	16	99	231:20
	80	5:20					7	3	7	9	11	13	17	20	23	23	16	99	253:20
	100	5:20					7	5	9	11	13	17	19	20	23	23	16	99	267:20
	120	5:20					7	7	12	13	16	17	19	20	23	23	16	99	277:20
320	10	6:20							7	0	0	0	4	3	3	7	10	56	96:20
Max O_2 = 12.2%	20	6:00						7	0	0	3	5	5	6	8	10	10	88	148:00
Min O_2 = 10.0%	30	5:40					7	0	0	4	4	6	7	9	11	17	13	98	181:40
	40	5:40					7	0	4	4	6	7	9	12	16	20	16	99	205:40
	60	5:20				7	0	2	6	8	9	11	14	17	23	23	16	99	240:20
	80	5:20				7	0	6	8	8	13	14	19	20	23	23	16	99	261:20
	100	5:20				7	2	7	10	13	16	17	19	20	23	23	16	99	277:20
	120	5:20				7	4	9	12	13	16	17	19	20	23	23	16	99	283:20
330	10	6:20						7	0	0	0	2	3	3	4	7	10	59	101:20
Max O_2 = 11.8%	20	6:00					7	0	0	2	3	4	6	5	10	10	10	90	153:00
Min O_2 = 10.0%	30	6:00					7	0	1	4	5	6	8	8	13	17	14	98	187:00
	40	5:40				7	0	1	4	5	7	7	10	12	17	22	16	99	212:40
	60	5:40				7	0	5	6	8	9	11	15	20	23	23	16	99	247:40
	80	5:40				7	2	7	8	10	13	15	19	20	23	23	16	99	267:40
	100	5:40				7	5	9	9	13	16	17	19	20	23	23	16	99	281:40
	120	5:20			7	1	7	10	13	15	16	17	19	20	23	23	16	99	291:20
340	10	6:40						7	0	0	0	3	3	3	4	7	10	61	104:40
Max O_2 = 11.5%	20	6:20					7	0	0	2	4	5	7	8	9	10	10	90	158:20
Min O_2 = 10.0%	30	6:00				7	0	0	3	5	5	6	8	9	13	18	14	98	192:00
	40	6:00				7	0	2	4	6	7	8	10	13	16	22	16	99	216:00
	60	5:40			7	0	3	5	6	9	10	13	16	18	21	23	16	99	251:40
	80	5:40			7	0	7	7	8	11	13	15	19	20	23	23	16	99	273:40
	100	5:40			7	2	8	8	12	13	16	17	19	20	23	23	16	99	288:40
	120	5:40			7	4	9	11	13	15	16	17	19	20	23	23	16	99	297:40
350	10	6:40					7	0	0	0	2	2	3	3	5	7	10	64	109:40
Max O_2 = 11.2%	20	6:20				7	0	0	0	4	4	5	5	7	9	13	10	94	164:20
Min O_2 = 10.0%	30	6:20				7	0	1	4	4	5	7	8	11	13	18	14	99	197:20
	40	6:00			7	0	1	3	5	6	7	8	11	14	17	23	16	99	223:00
	60	6:00			7	0	5	5	8	8	11	12	16	19	23	23	16	99	258:00
	80	6:00			7	2	7	7	10	11	13	17	19	20	23	23	16	99	280:00
	100	5:40		7	0	6	8	9	11	15	16	17	19	20	23	23	16	99	294:40
	120	5:40		7	1	7	9	12	14	15	16	17	19	20	23	23	16	99	303:40

* Does not include oxygen shiftover time

Table 11-4. Surface-Supplied Helium Oxygen Decompression Table - Continued.

Depth (fsw)	Bottom Time (min.)	Time to First Stop (min:sec)	Decompression Stops (fsw) 190	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	Total Ascent Time* (min:sec)
			Bottom Mix									40% O_2					100% O_2		
360 Max O_2 = 10.9% Min O_2 = 10.0%	10	7:00					7	0	0	0	2	2	2	3	7	7	10	66	113:00
	20	6:40				7	0	0	2	3	4	5	5	8	10	13	10	94	167:40
	30	6:20			7	0	0	3	3	5	6	7	8	11	13	19	15	99	202:20
	40	6:20			7	0	2	4	5	7	7	9	10	14	20	23	16	99	229:20
	60	6:20			7	2	5	6	7	9	11	14	16	19	23	23	16	99	263:20
	80	6:00		7	0	6	6	8	11	12	14	16	19	20	23	23	16	99	286:00
	100	6:00		7	2	7	8	11	13	13	16	17	19	20	23	23	16	99	300:00
	120	6:00		7	4	8	10	12	14	15	16	17	19	20	23	23	16	99	309:00
370 Max O_2 = 10.6% Min O_2 = 10.0%	10	7:00				7	0	0	0	0	3	3	3	3	7	7	10	68	118:00
	20	6:40			7	0	0	0	3	4	4	5	5	8	10	13	12	94	171:40
	30	6:20		7	0	0	2	3	4	4	7	7	8	11	16	19	16	99	209:20
	40	6:20		7	0	0	4	4	5	6	8	10	11	14	20	23	16	99	233:20
	60	6:20		7	0	4	5	7	8	9	11	13	17	20	23	23	16	99	268:20
	80	6:00	7	0	3	6	7	9	10	12	15	17	19	20	23	23	16	99	292:00
	100	6:00	7	0	6	7	9	10	14	15	16	17	19	20	23	23	16	99	307:00
	120	6:00	7	1	7	9	11	13	14	15	16	17	19	20	23	23	16	99	316:00
380 Max O_2 = 10.4% Min O_2 = 10.0%	10	7:20				7	0	0	0	0	3	3	3	3	7	7	10	68	118:20
	20	7:00			7	0	0	0	3	4	4	5	5	8	10	13	12	94	172:00
	30	6:40		7	0	0	2	3	4	4	7	7	8	11	16	19	16	99	209:40
	40	6:40		7	0	0	4	4	5	6	8	10	11	14	20	23	16	99	233:40
	60	6:40		7	0	4	5	7	8	9	11	13	17	20	23	23	16	99	268:40
	80	6:20	7	0	3	6	7	9	10	12	15	17	19	20	23	23	16	99	292:20
	100	6:20	7	0	6	7	9	10	14	15	16	17	19	20	23	23	16	99	307:20
	120	6:20	7	1	7	9	11	13	14	15	16	17	19	20	23	23	16	99	316:20

* Does not include oxygen shiftover time

problem can be remedied quickly, reventilate the diver with oxygen and resume the schedule at the point of interruption. Consider any time on air or helium oxygen as dead time. If the problem cannot be remedied, keep the diver on air or helium oxygen and use the Emergency Procedures Decompression Table (Table 11 1) to complete the decompression. Any time spent on oxygen at 50 fsw counts as decompression time on the Emergency Procedures Decompression Table.

If it is not possible to shift the diver back to 60 percent helium/40 percent oxygen, or if the 60 percent helium/40 percent oxygen supply is also lost during the subsequent decompression, shift the diver to air and complete the dive on open circuit using the Emergency Procedures Decompression Table. Any time spent on oxygen or 60 percent helium/40 percent oxygen counts toward decompression time on the Emergency Procedures Decompression Table.

The diver can be surface decompressed from the Emergency Procedures Decompression Table when the 30 fsw in water stop is completed. Surface the diver at 30 fsw/minute and recompress in the chamber to 40 fsw. The time from leaving 30 fsw in the water to arriving at 40 fsw in the chamber cannot exceed five minutes. The number of oxygen breathing periods in the chamber is determined with the same method as for normal surface decompression on the original schedule.

11.4.5 Loss of Oxygen Supply at the 40 Foot Stop. In the event that the diver cannot be shifted to oxygen at 40 fsw or the oxygen supply is lost during the 40 fsw stop, take the following action.

If the loss occurs before the diver is within emergency surface decompression limits, proceed as follows: If 60 percent helium/40 percent oxygen is available on the console, shift the diver to that mixture. If 60 percent helium/40 percent oxygen is not available, shift the diver to air. If the loss can be remedied quickly, reventilate the divers with oxygen and resume the schedule at the point of interruption. Consider any time on air or helium oxygen as dead time. If the loss of oxygen is permanent, have the divers remain on air or helium oxygen and use the Emergency Procedures Decompression Table to complete the decompression. Time spent on oxygen at 40 fsw counts toward decompression on the Emergency Procedures Decompression Table. Surface decompression can be used after completion of the 30 foot stop.

If the diver is within Emergency Sur D limits when the oxygen supply is lost, surface the diver and complete decompression in accordance with Emergency Sur D procedures.

If the diver is within Normal Sur D limits when the oxygen supply is lost, surface the diver and complete decompression in accordance with Normal Sur D procedures.

If the loss occurs in the chamber, have the diver breathe chamber air. If the loss is temporary, return the diver to oxygen breathing. Consider any air time as dead time. If the loss is permanent, follow the Emergency Procedures Decompression Table to the surface. Any time already spent on oxygen or air at 40 fsw counts toward decompression time on the Emergency Procedures Decompression Table.

11.4.6 Oxygen Supply Contaminated with Helium Oxygen. Shift the divers to helium oxygen or air, whichever has the highest percentage of oxygen. Find the contamination source and correct the problem. The probable sources of contamination include accidental opening of the EGS valve on the MK 21 MOD 1, or an improper valve line up on the console.

When the problem is corrected, shift the divers back to oxygen, ventilate each diver with 10 scf of oxygen for MK 21, and restart the stop time. Disregard all previous time spent at the stop, i.e., treat as dead time.

11.4.7 Central Nervous System (CNS) Oxygen Toxicity Symptoms (Nonconvulsive) at the 50 Foot Stop. Bring the divers up ten feet and shift to air to reduce the partial pressure of oxygen. Shift the console as the divers are traveling.

Upon reaching the 40 foot stop, maintain communications as the buddy or standby diver monitors the stricken diver.

Ventilate both divers (the stricken diver first). Sur D after completion of the 30 foot stop on the Emergency Procedures Decompression Table. Disregard the missed time at 50 fsw. If the diver convulses at 40 fsw in spite of these measures, follow the procedures outlined in Paragraph 11.4.9.

11.4.8 CNS Oxygen Toxicity Symptoms (Nonconvulsive) at the 40 Foot Stop. If symptoms appear before the diver is within emergency surface decompression limits, ascend to the 30 foot stop and shift to air. Surface decompress after completion of the 30 foot stop on the Emergency Procedures Decompression Table. Disregard missed time at 40 feet. If the diver convulses at 30 fsw in spite of these measures, follow the procedures outlined in Paragraph 11.4.9.

If symptoms occur after the diver is within emergency surface decompression limits, surface decompress the diver using emergency Sur D procedures.

If symptoms occur after the diver is within normal surface decompression limits, surface decompress the diver using normal Sur D procedures.

If symptoms occur during the chamber stop, remove the mask. Fifteen minutes after all symptoms have completely subsided, resume oxygen breathing at the point of interruption. Complete all required oxygen breathing time. If the diver cannot tolerate oxygen at all, complete decompression on chamber air using the stops of the Emergency Procedures Decompression Table. All previous time on oxygen and air at 40 fsw in the chamber counts toward decompression when a shift to this table is made.

11.4.9 CNS Oxygen Convulsion at the 50 Foot Stop or 40 Foot Stop. If oxygen symptoms advance to convulsions, or if the diver is presumed to be convulsing at the 50 foot stop or 40 foot stop, a serious emergency has developed. Only general management guidelines can be presented here.

Topside supervisory personnel must take whatever action they deem necessary to bring the casualty under control.

Shift the divers to air. Have the unaffected diver ventilate himself and then ventilate the stricken diver. Hold the divers at depth until the tonic clonic phase of the sequence has subsided. The tonic clonic phase of a convulsion generally lasts one to two minutes. If only one diver is in the water, launch the standby diver immediately and have him ventilate the stricken diver.

If consciousness is quickly regained and voice communication reestablished, the stricken diver may be tended by the standby diver or the buddy diver and decompressed according to one of two options. If the diver was eligible for emergency or normal surface decompression prior to the seizure, allow a short period for stabilization and then decompress using

Table 11-6. U.S. Navy Treatment Table 8 for Deep Blowup.

Depth (fsw)	Max Time at Initial Treatment Depth (hours)	2-fsw Stop Times (minutes)
225	0.5	5
165	3	12
140	5	15
120	8	20
100	11	25
80	15	30
60	Unlimited	40
40	Unlimited	60
20	Unlimited	120

Notes:

1. Enter the table at the depth, which is exactly equal to or next greater than the deepest depth attained in the recompression. The descent rate is as fast as tolerable.

2. The maximum time that can be spent at the deepest depth is shown in the second column. The maximum time for 225 fsw is 30 minutes; for 165 fsw, three hours. For an asymptomatic diver, the minimum time at depth is 30 minutes for depths exceeding 165 fsw and two hours for depths equal to or shallower than 165 fsw.

3. Decompression is begun with a 2-fsw reduction in pressure if the depth is an even number. Decompression is begun with a 3-fsw reduction in pressure if the depth is an odd number. Subsequent stops are carried out every 2 fsw. Stop times are given in column three. The stop time begins when leaving the previous depth. Ascend to the next stop in approximately 30 seconds.

4. Stop times apply to all stops within the band up to the next quoted depth. For example, for ascent from 165 fsw, stops of 12 minutes are made at 162 fsw, and at every two-foot interval to 140 fsw. At 140 fsw, the stop time beomes 15 minutes. When traveling from 225 fsw, the 166-foot stop is five minutes; the 164-foot stop is 12 minutes. Once begun, decompression is continuous. For example, when decompressing from 225 feet, ascent is not halted at 165 fsw for three hours. However, ascent may be halted at 60 fsw and shallower for any desired period of time.

5. While deeper than 165 fsw, a helium-oxygen mixture with 16-21 percent oxygen may be breathed by mask to reduce narcosis. At 165 fsw and shallower, a 60-percent helium/40-percent oxygen mixture or a 60-percent nitrogen/40-percent oxygen mixture may be given to the diver as treatment gas. For all treatment gases (HeO_2, N_2O_2, and O_2), a schedule of 25 minutes on gas and five minutes on chamber air should be followed for a total of four cycles. Additional oxygen may be given at 60 fsw after a two-hour interval of chamber air. See USN Treatment Table 7 (Volume One, Chapter Eight) for guidance.

6. To avoid loss of the chamber seal, ascent may be halted at four fsw and the total remaining stop time of 240 minutes taken at this depth. Ascend directly to the surface upon completion of the required time.

7. Total ascent time from 225 fsw is 56 hours, 29 minutes. For a 165-fsw recompression, total ascent time is 53 hours, 52 minutes, and for a 60-fsw recompression, 36 hours, 0 minutes.

11.4.11 Lightheaded or Dizzy Diver on the Bottom. Dizziness is a common term used to describe a number of feelings, including lightheadedness, unsteadiness, vertigo (a sense of spinning), or the feeling that one might pass out. There are a number of potential causes of dizziness in surface supplied diving including carbon dioxide accumulation, hypoxia, a gas supply contaminated with toxic gases such as methylchloroform, and trauma to the inner ear caused by difficult clearing of the ear. At the low levels of oxygen percentage specified for surface supplied diving, oxygen toxicity is an unlikely cause unless the wrong gas has been supplied to the diver.

The first step to take is to have the diver stop work and ventilate the rig while topside checks the oxygen content of the supply gas. These actions should eliminate carbon dioxide and hypoxia as causes. If ventilation does not improve symptoms, the cause may be a contaminated gas supply. Shift banks to the standby helium oxygen supply and continue ventilation. If the condition clears, isolate the contaminated bank for future analysis, and abort the dive on the standby gas supply. If the entire gas supply is suspect, place the diver on the EGS and abort the dive. Follow the guidance of Paragraph 11.4.2 for ascents.

Vertigo due to inner ear problems will not respond to ventilation, and in fact may worsen. One form of vertigo, however, alternobaric vertigo, may be so short lived that it will disappear during ventilation. Alternobaric vertigo will usually occur just as the diver arrives on the bottom and often can be related to a difficult clearing of the ear. It would be unusual for alternobaric vertigo to occur after the diver has been on the bottom for more than a few minutes. Longer lasting vertigo due to inner ear barotrauma will not respond to ventilation and will be accompanied by an intense sensation of spinning and marked nausea. Also, it is usually accompanied by a history of difficult clearing during the descent. These characteristic symptoms may allow the diagnosis to be made. A wide variety of ordinary medical conditions may also lead to dizziness. These conditions may occur while the diver is on the bottom. If symptoms of dizziness are not cleared by ventilation and/or shifting to alternate gas supplies, have the dive partner or standby diver assist the diver(s) and abort the dive.

11.4.12 Unconscious Diver on the Bottom. An unconscious diver on the bottom constitutes a serious emergency. Only general guidance can be given here. Management decisions must be made on site, taking into account all known factors. The advice of a Diving Medical Officer shall be obtained at the earliest possible moment.

If the diver becomes unconscious on the bottom, first take steps to ensure that the breathing medium is adequate and that the diver is breathing. Check the status of any other divers. If there is any reason to suspect gas contamination, shift to the standby helium oxygen supply. Have the dive partner or standby diver ventilate the afflicted diver to remove accumulated carbon dioxide in the helmet and ensure the correct oxygen concentration. When ventilation is complete, have the dive partner or standby diver ascertain whether the diver is breathing. In the MK 21, the presence or absence of breath sounds will be audible over the intercom. If the diver appears not to be breathing, the dive sensor one, two, or three. This output is sufficient to activate the meter and does not require signal amplification.

- **MK 16 displays.** The primary display (shown in Figure 13-5) consists of two light-emitting diodes (LEDs) which are contained within the primary display housing. This display is normally mounted on the right side of the face mask, within the peripheral vision of the diver. The two LEDs (one red and one green) powered by the electronics subassembly battery indicate the general overall condition of various electronic components and the ppO_2 in the breathing loop as follows:

  Steady green - Normal oxygen range, 0.60 to 0.90 ata ppO_2 (using a set point of 0.75 ata)

  Steady red or simultaneously illuminated steady red and green - primary electronics failure

  Flashing green - High oxygen content, greater than 0.90 ata ppO_2

  Flashing red - Low oxygen content, less than 0.60 ata ppO_2

  Alternating red/green - Normal transition period (ppO_2 is transitioning from normal to low, from low to normal, from normal to high, or from high to normal)

  One sensor out of limits

  Low primary battery power (displayed on secondary display)

  Voltage regulator failure

  No display (display blanked) - Electronics assembly or primary battery failure

  The MK 16 secondary display (Figure 13-5) is designed to provide quantitative information to the diver on the condition of the breathing medium, the primary battery voltage, and the condition of the secondary batteries. It also serves as a backup for the primary display in the event of a failure or malfunction to either the electronics subassembly, the primary display, or the primary power supply. The secondary display functions concurrently with, but independently of the primary display, and displays ppO_2 and primary battery information in digital form. The secondary display is independently powered by four 1.5-volt batteries. It does not rely on the primary electronics subassembly, but receives signals directly from the oxygen sensors and the primary battery. It will continue to function in the event of a primary electronics subassembly failure.

13.4 OPERATIONAL PLANNING

Because the MK 15 and MK 16 UBAs maintain a constant partial pressure of oxygen and add oxygen or diluent gas only as needed, dives of long duration are possible.

Mission capabilities, dive procedures, and decompression procedures are radically different from any other methods. This requires a high level of diver training and awareness, and necessitates careful dive planning. Volume One, Chapter Four, provides general guidelines for operational planning. The information provided in this section is supplemental to information in Chapter Four and provides specific guidelines for MK 15 and MK 16 UBA dive planning. In addition to any other requirements, at least half of all dive training should be at night or in conditions of restricted visibility. Units requiring a deep operational capability should allow frequent opportunity for training, ensuring diver familiarity with equipment and procedures. **Workup dives are recommended prior to diving at depths greater than 130 fsw.** MK 16 diver qualifications may be obtained by either completing the MK 16 Basic Course (A-431-0075) or the Naval Special Warfare Center MK 16 Qualification Course. MK 16 qualifications remain in effect as long as EOD diver qualifications are maintained. However, an EOD diver who has not made a MK 16 dive in the previous six months must refamiliarize himself with MK 16 EPs and OPs and must complete a MK 16 training dive prior to making a MK 16 operational dive. Prior to conducting MK 16 decompression diving, an EOD diver who has not conducted a MK 16 decompression dive within the previous six months must complete open water decompression training dives.

13.4.1 Operating Limitations. Use of combat swimmer multilevel dive (CSMD) procedures provides SPECWAR divers with the option of conducting multiple-depth diving with the MK 15 UBA if a maximum depth of 70 fsw (NEDU Report 13-83) is not exceeded at any time during the dive.

Diving Supervisors must consider the limiting factors presented in the following paragraphs when planning closed-circuit UBA operations.

13.4.1.1 Oxygen Flask Endurance. In calculating the endurance of the MK 15/16, only the oxygen flask is considered. The endurance of the oxygen flask is dependent upon the following:

- Flask floodable volume
- Initial predive pressure
- Required reserve pressure
- Oxygen consumption by the diver
- Effect of cold water immersion on flask pressure

The oxygen flask floodable volume (fv) is 0.1 cubic foot (2.9 liters).

The initial pressure is the pressure of the oxygen flask at ambient temperature when it has cooled following charging. A reserve pressure of 500 psig is required to drive the reducer. Calculation of initial pressure must also account for gas loss resulting from UBA predive calibration. Oxygen consumption by the diver is computed as 0.049 scfm (1.4 lpm). This is a conservative value for a diver swimming at 0.85 knot (Volume 1, Table 3-1).

Immersion in cold water will reduce the flask pressure and standard cubic feet (scf) of gas available for the diver, in accordance with the General Gas Law. Based upon direct measurement, available data, or experience, the coldest temperature expected during the dive is used.

Combining these factors produces the formula for MK 15/16 gas endurance:

MK 15/16 gas endurance =

$$FV \times \frac{\left[\left(\quad T \quad \right) - P_R\right]}{VO_2 \times 14.7\ \text{psi}} \times \frac{492}{T_2}$$

Where:

FV = Floodable volume of flask in cubic feet

P_I = Initial Pressure in psia

P_R = Reserve Pressure in psia

VO_2 = Oxygen consumption in medical scfm (32°F)

T_1 = Ambient air temperature in °R

T_2 = Coldest water temperature expected in °R

Rankin conversion factor:

°R = °F + 460

All pressure and temperature units must be absolute.

Example: The endurance of a MK 15/16 MOD 0 UBA charged to 2,500 psig for a dive in 50°F water when the ambient air temperature is 65°F would be computed as follows:

MK 15/16 gas endurance =

$$.1 \times \frac{[(2514.7 \times 510/525) - 514.7]}{0.049 \times 14.7} \times \frac{492}{510}$$

= 258 minutes

For practical purposes, these calculations can be simplified to:

$$\frac{FV(P_I - P_R)}{VO_2 \times 14.7} =$$

$$\frac{.1(2514.7 - 514.7)}{0.049 \times 14.7} = 277 \text{ minutes}$$

This duration assumes no gas loss from the UBA during the dive and only considers metabolic consumption of oxygen by the diver. Divers must be trained to minimize gas loss by avoiding leaks and unnecessary depth changes. Clearing a flooded face mask is a common cause of gas loss from the UBA. When a full face mask (FFM) is used, gas can pass from the UBA breathing loop into the FFM and escape into the surrounding seawater due to a poor face seal. Leaks which continue unchecked can deplete UBA gas supply rapidly. Additionally, during diver ascent, the dump valve opens to discharge breathing gas into the surrounding water, thereby preventing overinflation of the breathing diaphragm. Depth changes should be avoided as much as possible to minimize this gas loss.

13.4.1.2 Diluent Flask Endurance. Under normal conditions the anticipated duration of the MK 15/16 diluent flask will exceed that of the oxygen flask. The MK 15 and MK 16 diluent bottle holds approximately 21 standard cubic feet (595 liters) of gas at a stored pressure of 3,000 psig. Diluent gas is used to maintain the required gas volume in the breathing loop and is not depleted by metabolic consumption. As the diver descends, diluent is added to maintain the total pressure within the recirculation system at ambient water pressure. Loss of UBA gas due to offgassing at depth requires the addition of diluent gas to the breathing loop either automatically through the diluent add valve or manually through the diluent bypass valve to make up lost volume. Excessive loss of gas as a result of face mask leaks, frequent depth changes, or improper UBA assembly will deplete the diluent gas supply rapidly.

13.4.1.3 Canister Duration. The canister duration is estimated by using a working diver scenario. This allows an adequate safety margin for the diver in any situation. Tables 13-1 and 13-2 show the canister duration limits for the MK 15 and the MK 16 UBAs.

When using HP SODASORB, the MK 15 canister is limited to 400 minutes when the water temperature is 70°F and above.

For water temperatures between 40 and 69°F, canister duration is limited to 120 minutes. Canister duration is independent of depth in the 0-150 fsw range. Specific details are in the operations and maintenance manual for the MK 15 MOD O.

Using HP SODASORB, the MK 16 canister duration on helium-oxygen is 300 minutes in temperatures of 40-69°F. All other profiles can be dove to the limit line of the Closed-Circuit Mixed-Gas UBA Decompression Tables, provided that the diver has adequate thermal protection.

In temperatures below 40°F, the depth of the dive must be considered. If the dive is 100 fsw or shallower, the MK 16 canister will last five hours for a working diver. For excursions below 100 fsw with temperatures between 35°F and 39°F, the canister will last four hours. In temperatures between 29°F and 34°F, the canister will last only two hours.

MK 16 canister durations with nitrogen-oxygen are somewhat different than with helium-oxygen. For water temperatures 70°F and above, canister duration is 400 minutes and is independent of depth down to 300 fsw. For water temperatures below 40°F, canister duration is depth dependent. For dives between 0 and 50 fsw, the canister duration is 300 minutes. For dives from 51-150 fsw in water temperatures from 49-69°F, canister duration is 200 minutes. For dives from 51- 150 fsw in water temperatures from 29-39°F, canister duration is 100 minutes.

13.4.1.4 Thermal Protection. Divers must be equipped with adequate thermal protection to perform effectively and safely. A cold diver will either begin to shiver or increase his exercise rate, both of which will increase oxygen consumption and decrease oxygen supply duration and canister duration. Refer to Volume 1, Chapter 4, for guidance on thermal protection.

Table 13-1. MK 15 Canister Duration Limits.

Temperature	Depth	Time
70° F and above	0-150 fsw	400 minutes
40-69° F	0-150 fsw	120 minutes

Table 13-1a. MK 15 Canister Duration Limits for SDV Use Only.

Temperature	Depth	Duration
35-69° F	0-65 fsw	1300 psi oxygen tank drop

13.4.2 Equipment Requirements. Equipment requirements for closed-circuit mixed-gas UBA training dives are provided in Table 1-3. Two equipment items merit special comment:

- **Safety boat** - A **minimum** of one motorized safety boat **must** be present for an open water dive. A safety boat is recommended for tended pier dives or diving from shore. Safe diving practice in many situations, however, will require the presence of more than one safety boat. The Diving Supervisor must determine the number of boats required based on the diving area, medical evacuation plan, night operations and the number of personnel participating in the dive operation.

- **Buddy lines** - Buddy lines are considered important safety equipment for closed-circuit UBA dives. In special diving situations, such as certain combat swimmer operations or tended diving, the use of buddy lines may not be feasible. The Diving Supervisor shall conduct dives without buddy lines only in situations where their use is not feasible or where their use will pose a greater hazard to the divers than by diving without them.

13.4.2.1 MK 16 Specific Requirements.

Distance Line - Any buddy line over 10 feet in length is referred to as a distance line. The length of the distance line shall not exceed 25 meters. Distance lines shall be securely attached to both divers during Mine Countermeasure (MCM) Operations, Seal Delivery Vehicle (SDV) Operations, or Training.

NOTE

A distance line shall only be used by Command Designated MCM Detachment personnel.

Table 13-2. MK 16 Canister Duration Limits.

Canister Duration with HeO_2		
Temperature (°F)	**Depth (fsw)**	**Time (minutes)**
40 and above	0-300	300
29-39	0-100	300
35-39	101-300	240
29-34	101-300	120
Canister Duration with N_2O_2		
Temperature (°F)	**Depth (fsw)**	**Time (minutes)**
29 and above	0-50	300
40 and above	51-150	200
29-39	51-150	100

Table 13-3. MK 15/16 UBA (Untended) Diving Equipment Requirements.

General	Diving Supervisor	Divers	Standby Diver
1. Motorized safety boat (Note 1)	1. Dive watch	1. Dive watch (Note 2)	1. Dive Watch
2. Radio (communications with parent unit, chamber, communication between safety boats when feasible)	2. Dive pair list	2. Face mask	2. Face mask
3. High intensity, wide beam light (night operations)	3. U.S. Navy Standard Air Decompression Tables	3. Fins	3. Fins
4. Dive fllags and/or specialoperations lights as required.	4. Closed-Circuit Mixed-Gas UBA Decompression Tables Using 0.7 ATA Constant Partial Pressure Oxygen in Nitrogen and in Helium	4. Dive knife	4. Dive knife
	5. Recall device	5. Approved life preserver	5. Approved life preserver
		6. Appropriate thermal protection	6. Appropriate thermal protection
		7. Whistle	7. UBA with same depth capability
		8. Depth gauge (Note 2)	8. Depth gauge
		9. Compass (one per pair if on compass course)	9. Weight belt (if needed)
		10. Buddy line (as appropriate for EOD/ SPECWAR operations)	10. Tending line
		11. Gloves (Note 3)	
		12. Buoy (one per pair) (Note 3)	
		13. Slate with writing device (Note 3)	
		14. Buddy line (MK 15 SPECWAR operations) (Note 1)	

Notes:

1. See Paragraph 13.4.2
2. See Paragraph 13.4.2.1
3. Optional

Standby Diver - When appropriate during training and non-influence diving operations, open circuit SCUBA may be used to a maximum depth of 130 fsw.

Lines - Dive marker lines shall be manufactured from any light line that is buoyant and easily marked as directed in the following paragraph (one-quarter inch polypropylene is quite suitable).

Marking of Lines - Lines used for controlling the depth of the diver(s) are to be marked. This includes tending lines, marker lines, and lazy-shot lines. Lines are to be marked with red and yellow or black bands starting at the diver(s) or clump end. Red bands will indicate 50 feet and yellow or black bands will mark every 10 feet.

Dive Marker Buoy - Dive marker buoys will be constructed to provide adequate buoyancy to support the attached line. Additionally, the amount of line will be of sufficient length for the planned dive profile.

Depth Gauge/Wrist Watch - A single depth gauge and wrist watch may be used when diving with a partner and using a distance line.

13.4.3 Special Considerations. A recompression chamber and a Diving Medical Officer are not required on site as prerequisites for closed-circuit UBA diving operations. However, the following items should be determined prior to beginning diving operations:

- Location of the nearest functional recompression chamber - Positive confirmation of the chamber's availability in case of emergency should be obtained.
- Location of the nearest available Diving Medical Officer - If not at nearest recompression chamber.
- Location of the nearest medical facility - For treatment of injuries and medical problems not requiring recompression therapy.
- The optimal method of transportation to the treatment chamber or medical facility - If coordination with other units for aircraft/boat/vehicle support is necessary, the Diving Supervisor shall know the telephone numbers and points of contact necessary to make these facilities available as quickly as possible in case of emergency. A medical evacuation plan should be included in the Diving Supervisor brief. The preparation of an emergency assistance checklist similar to that in Volume One, Chapter Four, is recommended.

13.4.4 Ship Safety. When operations are to be conducted in the vicinity of ships, the guidelines provided in the Ship Repair Safety Checklist, Volume One, Chapter Four, must be followed.

13.4.5 Operational Area Clearance. Notification of intent to conduct diving operations should be coordinated in accordance with local directives.

13.5 CONDUCT OF THE DIVE

The Diving Supervisor must ensure that each diver has been formally trained and qualified in the diving equipment being used and does not suffer from any medical disorders which might affect mission performance or other members of the dive team.

13.5.1 Dive Briefing. A thorough, well prepared dive briefing reinforces the confidence level of the divers, increases safety, and is an important factor in successful mission accomplishment. It should normally be given by the Diving Supervisor, who will be in charge of all diving operations on the scene. The briefing shall be given separately from the overall mission briefing and shall focus on the diving portion of the operation, with special attention to the items shown in Table 13-4. MK 16 UBA

Line-Pull Dive Signals are listed in Table 13-5. For MK 16 UBA diving, the Diving Supervisor will ensure that the following information, unique to the MK 16, is recorded prior to the start of each MK 16 dive: MK 16 UBA serial number, MK 16 oxygen/diluent pressures, primary battery percentage, and EBS pressure. It is recommended that the Dive Record Sheet shown in Figure 13-8 be used by Diving Supervisors for MK 16 diving.

13.5.2 Diving Procedures for MK 16. The following procedures are used for MK 16 UBA diving operations. The purpose of marking the MK 16 divers with a buoy (subsequently referred to as "Marked Divers") is to provide the Diving Supervisor with a positive means of locating, recovering, and decompressing the divers. During dives requiring no decompression, the EOD Diving Officer may elect to eliminate the witness buoy. In considering whether to mark divers, the EOD Diving Officer should consider the visibility, environmental conditions, other lines in the water, and the experience level of the divers. Training and operational excercise dives employing an untended or unmarked single diver are not authorized. For Guidance on employing a single untended diver on live ordnance refer to paragraph 4-6.2.1 of Volume 1 of the U.S. Navy Dive Manual.

Diving methods include:

- Single Marked Diving. Consists of a single diver marked with a lightweight line attached to a surface float. Upon completion of a dive requiring decompression, the diver will signal the diving supervisor that he is ready to surface. The diving boat will then approach the surface float and recover the diver.

- Paired Marked Diving. Procedures for paired marked diving are identical to the procedures for a single marked diver, but with the addition of the second diver connected by a buddy/distance line.

- Tended Diving. Tended diving consists of a single surface tended diver or a pair of divers using a buddy/distance line, with one diver wearing a depth-marked line which is continuously tended at the surface. A dive pair working off a master reference buoy system may be treated as tended diving, provided the master reference buoy is closely and continuously monitored at the surface. Divers shall each be positively attached to the system or one diver positively attached to the system and the other diver positively attached to the first.

13.5.3 Equipment Preparation. As the divers set up their UBAs prior to the dive, the Diving Supervisor must ensure that each diver checks his own equipment, that setup is completed properly by checking the UBA, and that each diver reviews and signs an UBA predive checklist from the appropriate UBA operation and maintenance manual. The second phase of the Diving Supervisor check is a predive inspection conducted after the divers are dressed. The Diving Supervisor ensures that the UBA and related gear (life preserver, weight belt, etc.) are properly donned, that mission-related equipment (compass, depth gauge, dive watch, buddy lines, tactical equipment, etc.) are available, and that the UBA functions properly before allowing the divers to enter the water. Appropriate steps to confirm proper functioning of the UBA are provided in the appropriate operation and maintenance manual. Canister setups are valid for two weeks.

13.5.4 Dive Phase. The divers should adhere to the following guidelines as the dive is conducted:

Table 13-4. MK 15/16 UBA Dive Briefing.

A. Dive Plan	**F. Communications**
1. Operating depth	1. Frequencies, primary/secondary
2. Dive times	2. Call signs
3. CSMD tables or decompression tables	**G. Emergency Procedures**
4. Distance, bearing and transit times	1. Symptoms of CO_2 buildup
5. Known obstacles or hazards	2. Review of management of CO_2 toxicity, hypoxia, chemical injury, unconscious diver
B. Environment	3. UBA malfunction (refer to maintenance manual for detailed discussion
1. Weather conditions	• Oxygen sensor failure
2. Water/air temperatures	• Low partial pressure of oxygen
3. Water visibility	• High partial pressure of oxygen
4. Tides/currents	• Electronics failure
5. Depth of water	• Low Battery
6. Bottom type	• Diluent free flow
7. Geographic location	• Diluent addition valve failure
C. Personnel Assignments	• System flooding
1. Dive pairs	4. Lost swim pair procedures
2. Diving Supervisor	5. Omitted decompression plan
3. Diving Officer (Note 1)	6. Medical evacuation plan
4. Standby diver	• Nearest available chamber
5. Diving medical personnel	• Nearest Diving Medical Officer
6. Base of operations support personnel	• Transportation Plan
D. Special Equipment for:	• Recovery of other swim pairs
1. Divers (include thermal garment)	**H. Times for Operations**
2. Diving Supervisor	**I. Time Check**
3. Stanby diver	
4. Medical personnel	
E. Review of Dive Signals	
1. Hand signals	
2. MK 16 UBA Line-Pull Dive Signals (Table 1-5)	
Note 1: Diving Officer is not required on site.	

Table 13-5. MK 16 UBA Line-Pull Dive Signals.

Signal	From	To	Meaning
1 Pull	Diver	Tender	Arrived at lazy shot (given on lazy shot)
7 Pulls	Diver	Tender	I have started, found, or completed work.
2-3 Pulls	Diver	Tender	I have decompression symptoms
3-2 Pulls	Diver	Tender	Breathing from EGS
4-2 Pulls	Diver	Tender	Rig malfunction

a. Wear adequate thermal protection.

b. Know and use the proper amount of weights for the thermal protection worn and the equipment carried.

c. Check each other's equipment carefully for leaks at the start of the dive.

d. Do not exceed the UBA canister duration and depth limitations for the dive (Paragraph 13.4.1.3).

e. Minimize gas loss from the UBA (avoid mask leaks and frequent depth changes, if possible).

f. Maintain frequent visual or touch checks with buddy.

g. Be alert for symptoms suggestive of a medical disorder (Paragraph 13.7).

h. Use tides and currents to maximum advantage.

13.5.4.1 Descent. During descent, the UBA will automatically compensate for increased water pressure and provide an adequate volume of gas for breathing. During descent the oxygen partial pressure may increase as oxygen is added to the breathing mixture as a portion of the diluent. Depending on rate and depth of descent, the primary display on the MK 15 UBA may indicate "1" high (0.8 to 1.0 ata), red "H" (above 1.0 ata) or the red "A" alarm light (above 0.9 ata). The primary display on the MK 16 UBA may illuminate flashing green. It may take from two to ten minutes to consume the additional oxygen added by the diluent during descent. While breathing down the ppO_2, the diver should continuously monitor the secondary display until the ppO_2 returns to setpoint level. The oxygen- addition valve will not activate until the ppO_2 level is below the setpoint level.

13.5.4.2 At Depth. If the UBA is performing normally at depth, no adjustments will be required. The ppO_2 control system will add oxygen from time to time. Monitor UBA primary and secondary displays and high pressure gauges in strict accordance with applicable O & M Manual.

MK 16 MOD 0 DIVE RECORD SHEET		
Diving Supervisor		Date
Water Temp	Air Temp	Depth (fsw)
Table	Schedule	Planned Bottom Time
Required EBS Pressure		Actual EBS Pressure

	Name	Repet Group	Rig No.	O_2 Pressure	Diluent Pressure	Batt %	LS	LB	RS	TBT
Diver 1										
Diver 2										
Standby Diver										

Descent Rate	Scheduled Time at Stop		Stop Depth	Actual Time at Stop		Travel Time	Remarks
	Divers	Standby		Divers	Standby		
			10				
			20				
			30				
			40				
			50				
			60				
			70				
			80				

Figure 13-8. MK 16 MOD 0 Dive Record Sheet.

13.5.4.3 Ascent. As water pressure decreases, the diaphragm dump valve will compensate for the increased volume of gas by discharging some of the mixture into the water. During rapid ascent, Boyle's Law expansion of the gas may lower the ppO_2 faster than oxygen can be replaced by the automatic ppO_2 control system. In this case, the primary display on the MK 15 UBA may indicate "1" low (0.4 to 0.6 ata) and the "A" alarm light (below 0.5 ata) may illuminate. The primary display on the MK 16 UBA may flash red. This is considered normal operation. If the red "L" light (below 0.4 ata) turns on during ascent (continuously monitor the secondary display for equivalent ppO_2 values on the MK 16 UBA), decrease the rate of ascent or add oxygen to the breathing loop by depressing the oxygen-bypass valve briefly once every five seconds. Continually monitor the secondary display until the red "L" light turns off or the ppO_2 indicated is above 0.4 ata.

13.5.5 Postdive Procedures. Postdive procedures should be completed in accordance with the applicable operation and maintenance manuals.

13.6 DECOMPRESSION PROCEDURES

When diving with an open-circuit UBA, ppO_2 increases with depth. With a closed-circuit UBA, ppO_2 remains constant at a preset level regardless of depth. Therefore, standard U.S. Navy decompression tables cannot be used. Closed-circuit UBA users must use constant ppO2 decompression tables (air diluent, UBA MK 15 and 16; helium-oxygen diluent, UBA MK 16 only). Closed-circuit, mixed-gas UBA decompression tables (Tables 13-12 and 13-13) are included at the end of this chapter.

During decompression, it is very important to monitor the secondary display and maintain a 0.7 ppO_2 as nearly as possible. Always use the appropriate decompression table when surfacing, even if UBA malfunction has significantly altered the ppO_2.

Surface decompression is not authorized for MK 15 or MK 16 operations. Appropriate surface decompression tables have not been developed for constant 0.7 ata ppO_2 closed-circuit diving.

13.6.1 Rules for Using 0.7 ata Constant ppO_2 in Nitrogen and in Helium Decompression Tables.

NOTE

The rules using the 0.7 ata ppO_2 tables are the same for nitrogen and helium; however, the tables are not interchangeable.

a. These tables are designed to be used with a MK 15 or MK 16 UBA (or any other constant ppO_2 closed-circuit UBA) with an oxygen setpoint of 0.7 ata or higher.

b. When using helium as the inert gas, the amount of nitrogen must be minimized in the breathing loop. Flush the UBA well with helium-oxygen during set up and exhale completely before going on the UBA.

c. Tables are grouped by depth and within each depth group is a limit line. These tables are designed to be dived to the limit line. Schedules below the limit line provide for unforeseen circumstances when a diver might experience an inadvertent downward excursion or for an unforeseen reason overstay the planned bottom time.

d. Tables/schedules are selected according to the maximum depth obtained during the dive and the bottom time (time from leaving the surface to leaving the bottom).

e. General rules using these tables are the same as for standard air tables.

   (1) Enter the table at the listed depth that is exactly equal to or is next greater than the maximum depth attained during the dive.

   (2) Select the bottom time from those listed for the selected depth that is exactly equal to or is next greater than the bottom time of the dive.

   (3) Never attempt to interpolate between decompression schedules.

   (4) Use the decompression stops listed for the selected bottom time.

   (5) Ensure that the diver's chest is maintained as close as possible to each decompression depth for the number of minutes listed.

   (6) Ascent rate is less than or equal to 60 feet per minute.

   (7) Begin timing each stop on arrival at the decompression stop depth and resume ascent when the specified time has elapsed. Do not include ascent time as part of stop time.

   (8) The last stop may be taken at 20 fsw if desired. After completing the prescribed 20-fsw stop, remain at any depth between 10 fsw and 20 fsw inclusive for the 10-fsw stop time as noted in the appropriate decompression table.

   (9) Always use the appropriate decompression table when surfacing even if UBA malfunction has significantly altered ppO_2.

f. In emergency situations (e.g., UBA floodout or failure) a switch to emergency air may be made. Immediately ascend to the first decompression stop according to the original decompression schedule if deeper than the first stop. The subsequent decompression is modified according to the diluent gas originally breathed.

   Helium/oxygen diluent - Follow the original HeO2 decompression schedule without modification while breathing air.

   Nitrogen/oxygen diluent - Double all remaining decompression stops while breathing air. If the switch to emergency air is made while at a decompression stop then double the remaining time at that stop, and all shallower stops.

   If either of these procedures is used, the diver should be closely observed for signs of decompression sickness for two hours following the dive., but need not be treated unless symptoms arise.

g. When selecting the proper decompression table, all dives within the past 12 hours must be considered. Repetitive dives are allowed. Repetitive diving decompression procedures vary depending on the breathing medium(s) selected for past dives and for the current dive. See Table 13-6 for Repetitive Dive Procedures for Various Gas Mediums, Figure 13-9 for the Dive Worksheet for Repetitive 0.7 ata Constant Partial Pressure Oxygen in Nitrogen Dives, Table 13-7 for the No-Decompression Limits and Repetitive Group Designation Table for No-Decompression 0.7 ata Constant Partial

Table 13-6. Repetitive Dive Procedures for various Gas Mediums.

Selection of Repetitive Procedures for Various Gas Mediums		
Previous Breathing Medium (refer to Notes 1, 2, and 3)	**Current Breathing Medium**	**Procedure from Table 13-6a**
N_2O_2	N_2O_2	A
Air	N_2O_2	B
N_2O_2	Air	C
HeO_2	HeO_2	D
HeO_2	Air	E
Air	HeO_2	F
HeO_2	N_2O_2	G
N_2O_2	HeO_2	H

Notes:

1. If a breathing medium containing helium was breathed at any time during the 12 hour period immediately preceding a dive, use HeO_2 as the previous breathing medium.
2. If 100 percent oxygen rebreathers are used on a dive in conjunction with other breathing gases, treat that portion of the dive as if 0.7 ata O_2 in N_2 was breathed.
3. (For Combat Swimmer Multi-Level Dive (CSMD) only) If both air and 0.7 ata O_2 in N_2 are breathed during a dive, treat the entire dive as an air dive. If the 0.7 ata O_2 in N_2 is breathed at depths 80 fsw or deeper add the following correction factors to the max depth when selecting the appropriate air table.

Max Depth on N_2O_2	**Correction Factor**
Not exceeding 80 fsw	0
81-99	Plus 5
100-119	Plus 10
120-139	Plus 15
140-150	Plus 20

Table 13-6a. Repetitive Dive Procedures for Various Gas Mediums.

Notes:

A. (1) Use the Worksheet, Figure 13-9, for calculations.

(2) Determine the repetitive group letter for depth and time of dive conducted from Table 13-7 for No Decompression dives or from the Closed-Circuit Mixed-Gas UBA Decompression Tables (Tables 13-12 and 13-13) for decompression dives. If the exact time or depth is not found, go to the next longer time or the next deeper depth.

(3) Locate the repetitive group letter in Table 13-8. Move across the table to the correct surface interval time. Move down to the bottom of the column for the new group designation.

(4) Move down the column of the new group designation to the depth of the planned dive. This is the Residual Nitrogen Time (RNT). Add this to the planned bottom time of the next dive to find the decompression schedule and the new group designation.

(5) RNT Exception Rule: If the repetitive dive is to the same depth or deeper than the depth of the previous dive, and the RNT is longer than the original bottom time, use the original bottom time.

B. Use the repetitive group designation from the Standard Air Decompression Table or the No-Decompression Limits and Repetitive Group Designation Table for No-Decompression air dives to enter Table 13-8. Compute the RNT as in Procedure A. Do not use the Residual Nitrogen Timetable for repetitive air dives to find the RNT.

C. (1) Determine the repetitve group designation for depth and time of dive conducted from Table 13-7 or Table 13-12. If the exact time or depth is not found, go to the next longer time or the next deeper depth.

(2) Locate the repetitive group letter in Table 13-8. Move across the table to the correct surface-interval time. Move down to the bottom of the column for the new group designation.

(3) Use the repetitive group designation from Table 13-8 as the new group designation in the Residual Nitrogen Timetable for repetitive air dives (Volume 1, Chapter 7) to find the RNT.

D. Add the bottom time of the current dive to the sum of the bottom times for all dives within the past 12 hours to get the adjusted bottom time. Use the maximum depth attained within the past 12 hours and the adjusted bottom time to select the appropriate profile from Table 13-13.

E. Add the bottom times of all dives within the past 12 hours to get an adjusted bottom time. Using the Standard Air Decompression Table, find the maximum depth attained during the past 12 hours and the adjusted bottom time. The repetitive group from this air table may then be used as the surfacing repetitive group from the last dive. The Residual Nitrogen Timetable for repetitive air dives is used to find the repetitive group at the end of the current surface interval and the appropriate residual nitrogen time for the current air dive.

F. Compute the RNT from the Residual Nitrogen Timetable for repetitive air dives using the depth of the planned dive. Add the RNT to the planned bottom time to get the adjusted bottom time. Use Table 13-13 for the adjusted bottom time at the planned depth.

G. Add the bottom times of all dives within the past 12 hours to get an adjusted bottom time. Using Table 13-12, find the maximum depth attained during the past 12 hours and the adjusted bottom time. The repetitive group from the table may then be used as the surfacing repetitive group from the last dive. Table 13-8 is used to find the repetitive group at the end of the current surface interval and the appropriate RNT for the current dive.

H. Compute the RNT from Table 13-8 using the depth of the previous dive. Add the RNT to the planned bottom time to get the adjusted bottom time. Use Table 13-13 for the adjusted bottom time at the planned depth.

Repetitive Dive Worksheet for 0.7 ata N_2O_2 Dives

Part 1. Previous Dive: ________ minutes

________ feet

________ repetitive group designator from Table 13-7

Part 2. Surface Interval: ________ hours ________ minutes on the surface

________ final repetitive group from Table 13-8

Part 3. Equivalent Single Dive Time:

Enter Table 13-8 at the depth row for the new dive and the column of the final repetitive group to find the corresponding Residual Nitrogen Time (RNT).

________ minutes RNT

\+ ________ minutes planned bottom time

= ________ minutes equivalent single dive time

Part 4. Decompression Schedule for the Repetitive Dive:

________ minutes equivalent single dive time from Part 3.

________ feet, depth of the repetitive dive

Figure 13-9. Dive Worksheet for Repetitive 0.7 ata Constant Partial Pressure Oxygen in Nitrogen Dives.

Table 13.13 Closed-Circuit Mixed-Gas UBA Decompression Table Using 0.7 ata Constant Partial Pressure Oxygen in Helium.

(DESCENT RATE 60 FPM-ASCENT RATE 60 FPM)

(SCHEDULES BELOW THE LIMIT LINE ARE IN RED)

Depth (fsw)	Bottom Time (min.)	Time to First Stop (min:sec)	Decompression Stops (fsw) Stop Times (min)																			Total Ascent Time* (min:sec)
			190	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	
40	300	0:40																			0	0:40
	370	0:40																			0	0:40
	380	0:40																			0	0:40
	390	0:40																			0	0:40
50	205	0:50																			0	0:50
	210	0:40																			3	3:50
	220	0:40																			9	9:50
	230	0:40																			15	15:50
	240	0:40																			20	20:50
	250	0:40																			25	25:50
	260	0:40																			29	29:50
	270	0:40																			34	34:50
	280	0:40																			38	38:50
	290	0:40																			42	42:50
	300	0:40																			45	45:50
	310	0:40																			49	49:50
	320	0:40																			52	52:50
	330	0:40																			55	55:50
	340	0:40																			58	58:50
	350	0:40																			61	61:50
	360	0:40																			63	63:50
	370	0:40																			68	66:50
	380	0:40																			68	68:50
	390	0:40																			70	70:50
60	133	1:00																			0	1:00
	140	0:50																			8	9:00
	150	0:50																			20	21:00
	160	0:50																			30	31:00
	170	0:50																			40	41:00
	180	0:50																			50	51:00
	190	0:50																			59	60:00
	200	0:50																			67	68:00
	210	0:50																			75	76:00
	220	0:50																			83	84:00
	230	0:50																			90	91:00
	240	0:50																			97	98:00
	250	0:50																			103	104:00
	260	0:50																			109	110:00
	270	0:40																		2	112	115:00
	280	0:40																		7	113	121:00
	290	0:40																		12	113	126:00
	300	0:40																		17	113	131:00

Table 13.13 Closed-Circuit Mixed-Gas UBA Decompression Table Using 0.7 ata Constant Partial Pressure Oxygen in Helium - Continued.

(DESCENT RATE 60 FPM-ASCENT RATE 60 FPM)

(SCHEDULES BELOW THE LIMIT LINE ARE IN RED)

Depth (fsw)	Bottom Time (min.)	Time to First Stop (min:sec)	Decompression Stops (fsw) Stop Times (min) 190	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	Total Ascent Time* (min:sec)
60	310	0:40																		21	113	135:00
	320	0:40																		25	113	139:00
	330	0:40																		29	113	143:00
	340	0:40																		33	113	147:00
	350	0:40																		37	113	151:00
	360	0:40																		40	113	154:00
	370	0:40																		43	113	157:00
	380	0:40																		46	113	160:00
	390	0:40																		49	113	163:00
70	81	1:10																			0	1:10
	90	1:00																			6	7:10
	100	1:00																			13	14:10
	110	1:00																			19	20:10
	120	1:00																			35	36:10
	130	1:00																			50	51:10
	140	1:00																			65	66:10
	150	1:00																			79	80:10
	160	1:00																			92	93:10
	170	1:00																			104	105:10
	180	0:50																		7	109	117:10
	190	0:50																		14	113	128:10
	200	0:50																		25	112	138:10
	210	0:50																		34	113	148:10
	220	0:50																		44	112	157:10
	230	0:50																		52	113	166:10
	240	0:50																		60	113	174:10
	250	0:50																		68	113	182:10
	260	0:50																		76	112	189:10
	270	0:50																		83	112	196:10
80	51	1:20																			0	1:20
	60	1:10																			6	7:20
	70	1:10																			14	15:20
	80	1:10																			25	26:20
	90	1:10																			33	34:20
	100	1:00																		3	43	47:20
	110	1:00																		9	58	58:20
	120	1:00																		14	72	87:20
	130	1:00																		19	85	105:20
	140	1:00																		23	99	123:20
	150	1:00																		33	105	139:20
	160	1:00																		43	111	155:20

Table 13.13 Closed-Circuit Mixed-Gas UBA Decompression Table Using 0.7 ata Constant Partial Pressure Oxygen in Helium - Continued.

(DESCENT RATE 60 FPM-ASCENT RATE 60 FPM)

(SCHEDULES BELOW THE LIMIT LINE ARE IN RED)

Depth (fsw)	Bottom Time (min.)	Time to First Stop (min:sec)	Decompression Stops (fsw) Stop Times (min) 190	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	Total Ascent Time* (min:sec)
240	5	4:00																			0	4:00
	10	3:00														2	3	4	4	4	8	29:00
	15	2:30											2	4	3	4	4	9	9	10	22	71:00
	20	2:10									1	3	4	4	7	9	10	9	18	22	23	114:00
	25	2:10									4	3	9	9	9	9	14	22	21	22	79	205:00
	30	2:00								1	7	9	9	10	9	20	22	22	22	42	113	290:00
	35	2:00								6	10	9	9	13	22	22	22	22	22	95	113	369:00
	40	1:50							3	9	9	9	17	22	22	22	22	22	53	113	113	440:00
	45	1:50							7	9	9	19	22	22	22	21	22	22	102	112	113	506:00
	50	1:50							9	10	19	22	21	22	22	22	22	52	113	113	113	564:00
245	5	3:55																			1	5:05
	10	3:05														3	3	4	4	4	9	31:05
	15	2:35											3	4	4	3	5	9	10	11	22	75:05
	20	2:15									2	4	3	4	9	9	9	10	20	22	31	127:05
	25	2:05								1	4	5	9	9	9	10	15	22	22	22	90	222:05
	30	2:05								3	8	10	9	9	11	21	22	22	22	55	113	309:05
	35	1:55							1	9	9	10	9	16	22	22	22	21	22	111	113	391:05
	40	1:55							7	9	9	9	21	21	22	22	22	22	69	113	113	463:05
	45	1:45						1	10	9	10	22	21	22	22	22	22	28	111	113	113	530:05
	50	1:45						4	9	11	22	21	22	22	22	22	22	70	113	113	113	590:05
250	5	4:00																			1	5:10
	10	3:10														4	4	3	4	5	9	33:10
	15	2:30										1	4	3	4	4	6	9	9	14	21	79:10
	20	2:20									3	4	4	5	9	9	9	10	21	22	40	140:10
	25	2:10								3	4	6	9	9	10	9	18	21	22	22	102	239:10
	30	2:00							1	5	9	9	9	10	13	21	22	22	22	68	113	328:10
	35	2:00							5	9	9	9	10	19	22	21	22	22	34	113	113	412:10
	40	1:50						1	9	10	9	11	22	22	21	22	22	22	86	113	113	487:10
	45	1:50						5	10	9	13	22	22	22	22	22	21	44	113	113	113	555:10
	50	1:50						8	9	15	22	21	22	22	22	22	22	89	113	113	112	616:10
255	5	4:05																			2	6:15
	10	3:05													1	4	4	3	4	6	9	35:15
	15	2:35										2	4	4	3	4	7	9	10	14	22	83:15
	20	2:15								1	4	4	3	6	10	9	9	11	22	22	49	154:15
	25	2:05							1	4	3	8	9	10	9	9	20	22	22	21	113	255:15
	30	2:05							3	6	9	10	9	9	16	22	21	22	22	82	113	348:15
	35	2:05							8	10	9	9	10	21	22	22	22	22	47	113	113	432:15
	40	1:55						5	9	9	10	14	22	22	22	21	22	22	103	113	112	510:15
	45	1:55						9	9	10	17	22	22	21	22	22	22	61	113	112	113	579:15
	50	1:45					3	9	9	19	22	21	22	22	22	22	27	102	113	113	113	643:15

Table 13.13 Closed-Circuit Mixed-Gas UBA Decompression Table Using 0.7 ata Constant Partial Pressure Oxygen in Helium - Continued.

(DESCENT RATE 60 FPM-ASCENT RATE 60 FPM)

(SCHEDULES BELOW THE LIMIT LINE ARE IN RED)

Depth (fsw)	Bottom Time (min.)	Time to First Stop (min:sec)	190	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	Total Ascent Time* (min:sec)
260	5	4:10																			2	6:20
	10	3:10													2	4	4	3	4	6	10	37:20
	15	2:40										3	4	4	4	3	8	10	9	16	22	87:20
	20	2:20								3	3	4	4	7	10	9	9	13	22	22	58	168:20
	25	2:10							2	4	4	9	10	9	9	9	22	22	22	32	113	271:20
	30	2:00						1	3	9	9	9	9	10	18	22	21	22	22	95	113	367:20
	35	2:00						3	9	9	10	9	12	22	22	22	22	21	63	113	113	454:20
	40	2:00						9	9	9	10	17	22	22	22	22	21	31	110	112	113	533:20
	45	1:50					4	9	9	10	20	22	22	22	22	22	22	78	113	113	112	604:20
265	5	4:15																			3	7:25
	10	3:15													3	4	4	3	4	7	9	38:25
	15	2:35									1	4	4	3	4	4	9	9	9	19	22	92:25
	20	2:15							1	3	4	4	3	9	10	9	9	15	22	22	68	103:25
	25	2:15							4	4	5	10	9	9	9	12	22	22	21	45	113	289:25
	30	2:05						2	5	9	9	10	9	9	21	22	22	21	22	109	113	387:25
	35	2:05						6	10	9	9	9	16	22	22	21	22	22	78	113	113	476:25
	40	1:55					3	10	9	9	9	21	22	22	22	22	22	42	113	113	113	556:25
	45	1:55					8	9	9	12	22	22	22	22	21	22	22	97	112	113	113	630:25
270	5	4:20																			3	7:30
	10	3:10												1	3	4	4	3	4	8	9	40:30
	15	2:40									2	4	4	4	3	5	9	9	10	20	21	95:30
	20	2:20							2	4	3	4	5	9	9	10	9	17	22	22	77	197:30
	25	2:10						2	4	3	8	9	9	9	10	13	22	22	22	56	113	306:30
	30	2:10						4	7	9	9	9	10	10	22	22	22	21	32	113	113	407:30
	35	2:00					1	9	9	10	9	9	18	22	22	22	22	22	93	113	112	497:30
	40	2:00					7	10	9	9	12	21	22	22	22	22	22	60	113	112	113	580:30
	45	1:50				3	9	9	9	16	22	21	22	22	22	22	22	104	113	112	113	655:30
275	5	4:25																			4	8:35
	10	3:15												2	3	4	4	4	3	9	9	42:35
	15	2:45									4	4	3	4	4	5	10	9	9	22	22	100:35
	20	2:25							3	4	4	4	6	9	9	10	9	19	22	22	87	212:35
	25	2:15						4	3	4	9	9	9	10	9	16	22	21	22	69	113	324:35
	30	2:05					2	3	9	9	10	9	9	13	22	22	22	21	45	113	113	426:35
	35	2:05					5	9	9	9	10	9	21	22	22	22	21	27	104	113	113	520:35
	40	1:55				2	9	9	10	9	15	22	21	22	22	22	22	77	113	113	113	605:35
	45	1:55				7	9	9	9	19	22	22	22	22	22	21	44	110	113	113	113	681:35

Table 13.13 Closed-Circuit Mixed-Gas UBA Decompression Table Using 0.7 ata Constant Partial Pressure Oxygen in Helium - Continued.

(DESCENT RATE 60 FPM-ASCENT RATE 60 FPM)

(SCHEDULES BELOW THE LIMIT LINE ARE IN RED)

Depth (fsw)	Bottom Time (min.)	Time to First Stop (min:sec)	Decompression Stops (fsw) Stop Times (min)																			Total Ascent Time* (min:sec)
			190	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	
280	5	4:20																		1	4	9:40
	10	3:20												3	3	4	4	4	3	9	10	44:40
	15	2:40								1	4	4	4	3	4	7	9	9	12	21	22	104:40
	20	2:20						1	4	4	3	4	8	9	9	9	10	21	22	22	98	226:40
	25	2:10					1	4	4	5	9	9	10	9	9	18	22	22	22	80	113	341:40
	30	2:10					3	5	10	9	9	9	10	15	22	22	22	21	59	113	113	446:40
	35	2:00				1	7	10	9	9	9	12	22	22	21	22	22	37	109	113	113	542:40
	40	2:00				6	9	9	9	10	18	22	22	21	22	22	22	95	113	112	113	629:40
	45	1:50			1	9	10	9	10	22	22	22	21	22	22	22	59	113	113	113	113	707:40
285	5	4:25																		1	4	9:45
	10	3:25												4	3	4	4	4	4	9	11	47:45
	15	2:45								3	3	4	4	4	3	8	9	10	13	22	23	110:45
	20	2:25						3	4	3	4	4	9	9	9	9	12	22	22	21	108	243:45
	25	2:15					3	4	3	7	9	10	9	9	9	21	22	22	21	94	112	359:45
	30	2:05				1	4	7	9	9	10	9	9	18	22	22	22	22	73	113	113	467:45
	35	2:05				3	9	9	10	9	9	14	22	22	22	22	22	48	113	113	113	564:45
	40	2:05				10	9	9	9	10	21	22	22	22	21	22	32	101	113	113	113	653:45
	45	1:55			5	9	10	9	14	21	22	22	22	22	22	22	78	113	113	112	113	733:45
290	5	4:30																		2	4	10:50
	10	3:20											1	4	3	4	4	4	5	9	12	50:50
	15	2:50								4	4	3	4	4	4	9	9	9	15	22	31	122:50
	20	2:20					1	3	4	4	3	5	9	10	9	9	14	22	22	27	112	258:50
	25	2:10				1	4	3	4	8	10	9	9	9	11	22	22	21	26	102	113	378:50
	30	2:10				3	9	9	10	9	9	14	22	22	22	22	22	48	113	113	113	564:45
	35	2:10				6	10	9	9	9	10	17	22	22	22	21	22	66	112	113	113	587:50
	40	2:00			4	9	10	9	9	12	22	22	22	22	21	22	44	107	113	112	113	677:50
	45	2:00			9	9	10	9	17	22	22	22	22	21	22	27	92	113	113	112	113	759:50
295	5	4:35																		3	3	10:55
	10	3:25											2	4	3	4	4	4	5	9	14	53:55
	15	2:45							2	3	4	4	4	3	5	9	9	9	18	22	38	134:55
	20	2:25					2	4	3	4	4	6	9	9	10	9	16	22	22	36	113	273:55
	25	2:15				2	4	4	4	10	9	9	9	10	12	22	22	22	34	106	113	396:55
	30	2:05			1	4	5	9	9	9	10	9	10	22	22	22	22	27	97	113	113	508:55
	35	2:05			2	8	9	10	9	9	9	21	22	21	22	22	22	81	113	113	113	610:55
	40	2:05			8	9	9	10	9	15	22	22	22	22	22	21	56	113	112	113	113	702:55
300	5	4:40																		3	4	12:00
	10	3:30											3	4	3	4	4	4	6	9	15	57:00

Table 13.13 Closed-Circuit Mixed-Gas UBA Decompression Table Using 0.7 ata Constant Partial Pressure Oxygen in Helium - Continued.

(DESCENT RATE 60 FPM-ASCENT RATE 60 FPM)

(SCHEDULES BELOW THE LIMIT LINE ARE IN RED)

Depth (fsw)	Bottom Time (min.)	Time to First Stop (min:sec)	Decompression Stops (fsw) Stop Times (min)																			Total Ascent Time* (min:sec)
			190	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	
300	15	2:50							3	4	3	4	4	4	5	9	9	10	19	22	45	146:00
	20	2:30					4	3	4	4	3	8	9	9	10	9	18	22	22	47	112	289:00
	25	2:20				4	4	3	6	10	9	9	9	10	15	22	21	22	44	109	113	415:00
	30	2:10			2	4	7	9	10	9	9	9	13	22	22	22	22	37	101	113	113	529:00
	35	2:10			5	9	9	9	10	9	10	22	22	22	22	22	26	93	113	112	113	633:00
	40	2:00		3	9	9	9	10	9	18	22	22	22	22	22	22	73	113	112	113	113	728:00
310	6	4:30																3	4	4	3	19:10
	10	3:30										1	4	4	3	4	4	4	7	10	17	63:10
	15	2:50						2	4	3	4	4	3	4	8	9	9	12	22	21	60	170:10
	20	2:30				3	3	4	4	4	4	9	10	9	9	11	22	22	21	67	113	320:10
	25	2:20			3	4	4	4	9	9	9	10	9	9	20	22	22	22	65	113	113	452:10
	30	2:10		2	4	5	9	9	9	10	9	9	18	22	22	22	22	57	111	113	113	571:10
	35	2:10		3	9	9	9	10	9	9	17	21	22	22	22	22	48	103	113	113	113	679:10
	40	2:00	1	9	9	10	9	9	13	22	21	22	22	22	22	36	94	112	113	113	113	777:10
320	6	4:30															1	4	3	4	4	21:20
	10	3:40										3	4	4	3	4	4	4	9	9	20	69:20
	15	2:50					1	3	4	4	4	3	4	4	9	10	9	16	21	22	75	194:20
	20	2:30			2	4	3	4	4	4	7	9	9	10	9	16	22	21	25	88	112	354:20
	25	2:20		3	4	3	4	7	9	10	9	9	9	13	22	22	22	28	87	113	113	492:20
	30	2:10	1	4	4	9	9	9	9	10	9	11	21	22	22	22	26	82	113	112	113	613:20
	35	2:10	3	7	9	10	9	9	9	10	22	22	21	22	22	22	73	113	113	113	112	726:20
	40	2:10	9	9	9	9	10	9	19	22	22	21	22	22	22	60	107	113	113	113	112	828:20

d. The time limit for the excursion is determined by the maximum depth attained during the excursion (Table 14-2).

Table 14-2. Excursion Limits

Depth	Maximum Time
21-40 fsw	15 minutes
41-50 fsw	5 minutes

Note that the Excursion Limits are different from the Single- Depth Limits. The following is an example of a dive profile using the Transit with Excursion Limits:

A dive mission calls for a swim pair to transit at 20 fsw for 45 minutes, descend to 36 fsw, and complete their objective.

As long as the divers do not exceed a maximum depth of 40 fsw, they may use the 40-fsw excursion limit of 15 minutes. The time at which they initially descend below 20 fsw to the time at which they finish the excursion must be 15 minutes or less.

14.3.1.2 Inadvertent Excursions. If an inadvertent excursion should occur, one of the situations described below will apply:

a. If the depth and/or time of the excursion exceeds the limits in Paragraph 14.3.1.1 or if an excursion has been taken previously, the dive must be aborted and the diver must return to the surface.

b. If the excursion was within the allowed excursion limits, the dive may be continued to the maximum allowed oxygen dive time, but no additional excursions deeper than 20 fsw may be taken.

c. The dive may be treated as a single-depth dive applying the maximum depth and the total oxygen time to the Single-Depth Limits shown in Table 14-3.

Example: A dive pair is having difficulty with a malfunctioning compass. They have been on oxygen (Oxygen Time) for 35 minutes when they notice that their depth gauge reads 55 fsw. Since this exceeds the maximum allowed oxygen exposure depth, the dive must be aborted and the divers must return to the surface.

Example: A diver on a compass swim notes that his depth gauge reads 32 fsw. He recalls checking his watch five minutes earlier and at that time his depth gauge read 18 fsw. As his excursion time is less than 15 minutes, he has not exceeded the excursion limit for 40 fsw. He may continue the dive, but he must maintain his depth at 20 fsw or less and make no additional excursion.

NOTE

If the diver is unsure how long he was below 20 fsw, the dive must be aborted.

14.3.2 Single-Depth Limits. The term Single-Depth Limits does not mean that the entire dive must be spent at one depth, but refers to the time limit applied to the dive based on the maximum depth attained during the dive.

14.3.2.1 Single-Depth Limits Definitions. The following definitions apply when using the Single-Depth Limits:

Oxygen Time - Oxygen Time is calculated as the interval between On-Oxygen Time and Off-Oxygen Time as described in Paragraph 14.3.1.

Depth - The depth for the dive used to determine the allowable exposure time is determined by the maximum depth attained during the dive. For intermediate depth, the next deeper depth limit will be used.

14.3.2.2 Depth/Time Limits. The Single-Depth Limits are provided in Table 14-3. **No** excursions are allowed when using these limits.

Table 14-3. Single-Depth Oxygen Exposure Limits.

Depth	Maximum Oxygen Time
25 fsw	240 minutes
30 fsw	80 minutes
35 fsw	25 minutes
40 fsw	15 minutes
50 fsw	10 minutes

Example: Twenty-two minutes (Oxygen Time) into a compass swim, a dive pair descends to 28 fsw to avoid the propeller of a passing boat. They remain at this depth for eight minutes. They now have two choices for calculating their allowed Oxygen Time: (1) they may return to 25 fsw or shallower and use the time below 25 fsw as an excursion, allowing them to continue their dive on the Transit with Excursion Limits to a maximum time of 240 minutes; or (2) they may elect to remain at 28 fsw and use the 30 fsw Single- Depth Limits.

14.3.3 Exposure Limits for Specific Oxygen Dives. Certain unique situations arise with closed-circuit diving. The following paragraphs give details for these dives with special circumstances.

14.3.3.1 Previous Oxygen Dives. If an oxygen dive is being conducted after a previous closed-circuit oxygen exposure, the effect of the previous dive on the exposure limit for the subsequent dive is dependent on the Off-Oxygen Interval. The following definitions apply when using oxygen exposure limits for successive oxygen dives.

Off-Oxygen Interval - The interval between Off-Oxygen Time and On-Oxygen Time is defined as the time from when the diver discontinues breathing from his closed-circuit oxygen UBA on one dive until he begins breathing from the UBA on the next dive.

Successive Oxygen Dive - An oxygen dive which follows a previous oxygen dive after an Off-Oxygen Interval of less than two hours.

If an oxygen dive is a successive oxygen dive as defined above, the oxygen exposure limit for the dive must be adjusted as shown in Table 14-4. If the Off-Oxygen Interval is two hours or greater, no adjustment is required for the subsequent dive. An oxygen dive undertaken after an Off-Oxygen Interval of more than two hours is considered to be the same as an initial oxygen exposure.

NOTE

A maximum of four hours Oxygen Time is permitted within a 24 hour period.

If a negative number is obtained when adjusting the single-depth exposure limits as shown in Table 14-4, a two hour Off-Oxygen Interval must be taken before the next oxygen dive.

Example: Ninety minutes after completing a previous oxygen dive with an Oxygen Time of 75 minutes (maximum dive depth 19 fsw), a dive pair will be making a second dive using the Transit with Excursion Limits.

APPENDIX B

ACCIDENT/INCIDENT EQUIPMENT INVESTIGATION REQUIREMENTS

B-1 INTRODUCTION

An **accident** is an unexpected event which culminates in loss of or serious damage to equipment or injury to personnel. An **incident** is an unexpected event which degrades safety and increases the probability of an accident.

The number of diving accidents/incidents involving U.S. Navy divers is small when compared to the total number of dives conducted each year. The mishaps which do occur, however, must receive a thorough review to identify the cause and determine corrective measures to prevent further diving mishaps.

Appendix B expands on OPNAVINST 3100.6 series and 5102.1 series which require expeditious reporting and investigation of all diving related mishaps which result in a fatality or in personnel injury where there is lost time of 60 hours or more. The accident/incident equipment status reporting procedures in this appendix apply, in general, to all diving mishaps when malfunction or inadequate equipment performance, or unsound equipment operating and maintenance procedures are a factor. Reporting criteria and required actions are specified in paragraphs B-1 and B-2. In many instances a Diving Life Support Equipment Failure Analysis Report (FAR) may also be required. The primary purpose of this requirement is to identify any material deficiency which may have contributed to the mishap. Any suspected malfunction or deficiency of life support equipment will be thoroughly investigated by controlled testing at the Navy Experimental Diving Unit (NEDU). NEDU has the capability to perform engineering investigations and full unmanned testing of all Navy diving equipment under all types of pressure and environmental conditions. Depth, water turbidity and temperature can be duplicated for all conceivable U.S. Navy dive scenarios.

To assist diving units with investigations and data collection following a diving mishap, contact NAVSEA/00C3. 00C3 will assign a Representative to inspect the initial condition of equipment and to pick up or ship all pertinent records and equipment to NEDU for full unmanned testing. Equipment must not be tampered with after the accident and must be sent “as was” to NEDU (see OPNAVINST 3150.27). The test results will provide specific data indicating whether the equipment performs in accordance with specifications, or if not, will identify the deficient areas.

Upon receipt of the defective equipment, NEDU will conduct unmanned tests as rapidly as possible and will then return the equipment to the appropriate activity. In the event immediate operational requirements dictate a need, NEDU will identify interim replacement equipment.

B-2 REPORTING CRITERIA

The diving and diving related accident/incident equipment status requirements set forth in this appendix are mandatory for all U.S. Navy diving units in each of the following circumstances:

1. In all cases when an accident/incident results in a fatality or serious injury.

2. Whenever an accident/incident occurs and a malfunction or inadequate per-

formance of the equipment may have contributed to the accident/incident.

B-3 ACTIONS REQUIRED

U.S. Navy diving units shall perform the following procedure whenever a diving accident/incident or related mishap meets the criteria stated in Paragraph B-2.

1. Immediately secure and safeguard from tampering **all diver-worn and ancillary/support equipment** which may have contributed to the mishap. This equipment should also include, but is not limited to, the following: compressor, regulator, depth gauge, submersible pressure gauge, diver dress, buoyancy compensator/life preserver, weight belt and gas supply (SCUBA, emergency gas supply [EGS], etc.).

2. Expeditiously report circumstances of the accident/incident by message (see OPNAVINST 5102.1 series for format requirements) to:

    a. NAVSAFECEN NORFOLK VA//JJJ// with info copies to COMNAVSEASYSCOM WASHINGTON DC//00C// and NAVXDIVINGU PANAMA CITY FL//JJJ//.

    b. If MK 16 related, additionally info PEO MINEWAR WASHINGTON DC//PMO-EOD// and NAVEODTECHDIV INDIAN HEAD MD//70//.

    c. If MK 25 (LAR V) related, additionally info COMNAVSEA SYSCOM WASHINGTON DC//PMS340//.

3. Expeditiously prepare a **separate, written report** of the accident/incident. The report shall include:

    a. A completed Equipment Accident/Incident Information Sheet (Figure B-1)

    b. A completed Accident/Incident Equipment Status Data Sheet (Figure B-2)

    c. A sequential narrative of the mishap including relevant details that might not be apparent in the data sheets (Figures B-1 and B-2).

    d. The data sheets and the written narrative shall be mailed by traceable registered mail to:

Commanding Officer
Navy Experimental Diving Unit
321 Bullfinch Road
Panama City, Florida 32407-7015
Attn: Code 03, Test & Evaluation

NOTE

Call NAVSEA/NEDU with details of the mishap or incident whenever possible. Personal contact may prevent loss of evidence vital to the evaluation of the equipment.

NAVSEA 00C
Commercial: (703) 607-2766
DSN: 327-2766
Duty Officer (703) 602-7527

NEDU
Commercial: (904) 230-3100 or
(904) 235-1668
DSN: 436-4351

4. Package a certified copy of all pertinent 3M records and deliver to NAVSEA/00C3 on scene representative.

B-3.1 If the accident/incident is believed to be solely attributable to unsound operating and maintenance procedures, including publica-

EQUIPMENT ACCIDENT/INCIDENT INFORMATION SHEET

GENERAL

Unit point of contact ______________________ Position ______________________

Command UIC ______________ Date ______________ Time of occurrence ______________

____

EQUIPMENT (indicate type of all equipment worn/used) Contributing factor? ______________________

UBA: SCUBA ______________ MK21 ______________ MK20 ______________

MK 16 ______________ LAR V ______________

Other (specify) ______________________________________

Suit type: Dry ______________ Wet ______________ Hot water ______________

Other dress: Gloves ______________ Booties ______________ Fins ______________

Mask ______________ Snorkel ______________ Knife ______________

Weight belt (indicate weight) ______________________________

Depth gauge ______________ Last calibration date ______________

Buoyancy compensator/life preserver: ______________________________

Inflated at scene: ______________ Partially ______________ Operational ______________

Inflation mode: Oral ______________ CO_2 ______________ Independent supply ______________

Cylinders: Number worn ______________ Size (cu ft) ______________ Valve type ______________

Gas mix ______________ Aluminum ______________ Steel ______________

Surface pressure: Before ______________ After ______________

Regulator: ______________ Last PMS date? ______________ Functional at scene? ______________

Submersible pressure gauge: ______________ Functional at scene? ______________

CONDITIONS Location? ______________________________________

____

Depth ______________ fsw Visibility ______________ ft. Current ______________ Knots sea state ______________ (0-9)

Air temp ______________ °F Water temp: at surface ______________ °F at depth ______________ °F

Bottom type (mud, sand, coral, etc.) ______________________________

DIVE TIME

Bottom ______________ Decompression ______________ Total dive time ______________

Was equipment operating and maintenance procedure a contributing factor?

(Explain): ______________________________________

Is there contributory error in O&M Manual or 3M System?

(Explain): ______________________________________

OTHER CONTRIBUTING FACTORS ______________________________________

Figure B-1. Equipment Accident/Incident Information Sheet.

Accident/Incident Equipment Status Data Sheet

Pertaining to UBA involved, fill in blanks with data required by items 1 through 9.

MK 21	MK 20 MOD 0	SCUBA	MK 16	LAR V	OTHER
⬇	⬇	⬇	⬇	⬇	⬇

1. Number of turns to secure topside gas umbilical supply:

		N/A	N/A	N/A	

2. Number of turns to secure valve on emergency gas supply (EGS):

		Reserve Up/Down	N/A	N/A	

3. Number of turns to secure gas supply at mask/helmet:

		N/A	Mouthpiece Valve: Surface ________ Dive ________	Mouthpiece Valve: Surface ________ Dive ________	

4. Number of turns to secure gas bottle:

N/A	N/A	Air Bottle ________	O_2 ________ Diluent ________	O_2 Bottle ________	

5. Bottle Pressure:

EGS _____ psig	EGS _____ psig	_____ psig	O_2 _____ psig Diluent _____ psig	_____ psig	

6. Gas Mixture:

Primary % ______ EGS % ______		N/A	Diluent N_2O_2 _____ HeO_2 _____	N/A	

7. Data/color of electronic display:

N/A	N/A	N/A	Primary ________ Secondary ________ ________ ________	N/A	

8. Battery voltage level:

N/A	N/A	N/A	Primary ________ Secondary ________	N/A	

9. Condition of canister:

N/A	N/A	N/A			

Note: If UBA involved is not listed above, provide information on separate sheet.

Figure B-2. Accident/Incident Equipment Status Data Sheet.

tions, submit a NAVSEA (user) Technical Manual Deficiency/Evaluation Report (TMDER) and request guidance from NEDU to ascertain if shipment of all or part of the equipment is necessary.

B-3.2 In order to expedite delivery, SCUBA, MK 16 and EGS bottles will be shipped separately in accordance with current DOT directives and command procedures for shipment of compressed gas cylinders. Cylinders will be forwarded in their exact condition of recovery (e.g., empty, partially filled, fully charged).

B-3.3 If the equipment which is believed to be contributory to the accident/incident is sufficiently large to preclude economical shipment, NEDU should be contacted to determine alternate procedures.